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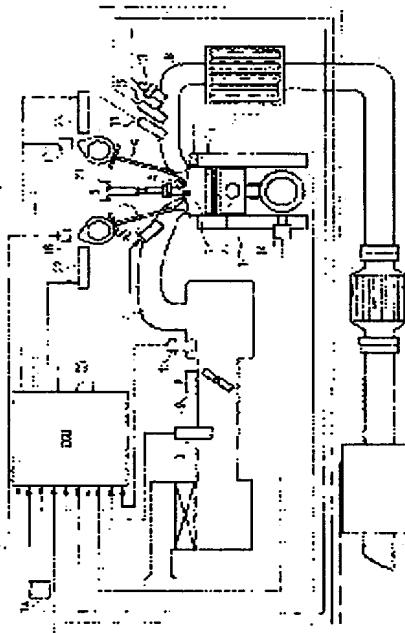
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## (54) INTERNAL EGR AMOUNT ESTIMATING DEVICE OF INTERNAL COMBUSTION ENGINE

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To precisely estimate an internal EGR amount from the quantity of state in the cylinder of the engine by using a physical equation.

**SOLUTION:** When an exhaust valve is closed, based on signals from an exhaust temperature sensor 12, an intake pressure sensor 10, and exhaust pressure sensor 11, a cylinder temperature and a cylinder pressure are calculated, the gas constant of exhaust gas according to a combustion air/fuel ratio is calculated, and a cylinder gas amount is calculated. Then, based on signals from a crank angle sensor 14, a water temperature sensor 15, cam angle sensors 16 and 17, and an accelerator opening sensor 18, a blowback gas amount during overlapping in an intake valve opening period and an exhaust valve opening period is calculated. Based on the calculated values of the cylinder gas amount and the blowback gas amount, the internal EGR amount is calculated.



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**CLAIMS**

[Claim(s)]

[Claim 1]

A means to compute whenever [ cylinder internal temperature / at the time of exhaust air bulb clausilium ],  
A means to compute the cylinder internal pressure at the time of exhaust air bulb clausilium,  
A means to compute the gas constant of the exhaust gas presentation according to a combustion air-fuel ratio,

A means to compute the capacity in a cylinder at the time of exhaust air bulb clausilium whenever [ said cylinder internal temperature ] based on said cylinder internal pressure and said gas constant at least,  
It has a means to blow under overlap of an exhaust air bulb open period and an intake valve open period, and to compute capacity,

The amount presumption equipment of internals EGR of the internal combustion engine characterized by the capacity in said cylinder, and said thing [ blowing and computing the amount of internals EGR based on capacity ].

[Claim 2]

It is a capacity calculation means in a cylinder at the time of said exhaust air bulb clausilium,

A means to compute the cylinder content volume at the time of exhaust air bulb clausilium,

A means to compute whenever [ cylinder internal temperature / at the time of said exhaust air bulb clausilium ],

A means to compute the cylinder internal pressure at the time of said exhaust air bulb clausilium,

A means to compute the gas constant of the exhaust gas presentation according to said combustion air-fuel ratio,

The amount presumption equipment of internals EGR of the internal combustion engine according to claim 1 characterized by consisting of \*\*\*\*\* and computing the capacity in a cylinder at the time of exhaust air bulb clausilium by the physical type based on these calculation values.

[Claim 3]

A cylinder content volume calculation means is the amount presumption equipment of internals EGR of the internal combustion engine according to claim 2 characterized by calculating the cylinder content volume value geometrically decided from the piston location at the time of exhaust air bulb clausilium at the time of said exhaust air bulb clausilium.

[Claim 4]

A cylinder content volume calculation means is the amount presumption equipment of internals EGR of the internal combustion engine according to claim 2 characterized by calculating the cylinder content volume value at the time of exhaust air bulb clausilium according to those variation in the engine which has the device in which the cylinder content volume of an exhaust air bulb clausilium stage and this stage is changed relatively at the time of said exhaust air bulb clausilium.

[Claim 5]

Said gas constant calculation means is the amount presumption equipment of internals EGR of the internal combustion engine of any one publication of claim 1 characterized by asking for the gas constant corresponding to change of an exhaust gas presentation - claim 4 according to target combustion equivalent ratio.

[Claim 6]

It blows during said overlap and is a capacity calculation means,

A means to compute whenever [ cylinder internal temperature / at the time of said exhaust air bulb clausilium ],

A means to compute the cylinder internal pressure at the time of said exhaust air bulb clausilium,  
A means to compute the gas constant corresponding to the exhaust gas presentation change according to said combustion air-fuel ratio,  
A means to compute a MAP,  
A means to compute the ratio of specific beat corresponding to exhaust gas presentation change,  
A means to compute the addition effective area under overlap of an exhaust air bulb open period and an intake valve open period,  
A means to compute an engine rotational frequency,  
A means to judge the existence of supercharge and a choke,  
The amount presumption equipment of internals EGR of the internal combustion engine of any one publication of claim 1 characterized by consisting of \*\*\*\*\*\*, blowing under overlap based on these calculation values, and computing capacity - claim 5.

[Claim 7]

Said supercharge and the judgment means of a choke,  
Based on cylinder internal pressure, it has a means to compute an inhalation-of-air exhaust-gas-pressure ratio, at the time of said MAP and said exhaust air bulb clausilium,  
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 characterized by setting it up when said supercharge judging means makes the ratio of specific beat corresponding to said exhaust gas presentation change those with supercharge.

[Claim 8]

It is an addition effective-area calculation means during said overlap,  
A means to compute intake valve closing motion timing,  
A means to compute exhaust air bulb closing motion timing,  
since -- the amount of overlap -- computing  
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 or 7 characterized by calculating the integrated value of effective area according to this amount of overlap.

[Claim 9]

It is an addition effective-area calculation means during said overlap,  
The amount presumption equipment of internals EGR of the internal combustion engine according to claim 6 or 7 characterized by computing addition effective area by integrating with either minimum value of the opening area in an inhalation-of-air valve lift, and the opening area in an exhaust air valve lift.

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[Translation done.]

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**DETAILED DESCRIPTION**

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**[Detailed Description of the Invention]**

[0001]

**[Field of the Invention]**

This invention relates to an internal combustion engine's amount (amount of reflux of emission gas) presumption equipment of internals EGR.

[0002]

**[Description of the Prior Art]**

In order to aim at reduction of NOx (nitrogen oxides) by the combustion-temperature control by the formation of inerts buildup, and fuel consumption reduction by reduction of a pump loss in a jump-spark-ignition type internal combustion engine from the former, using an adjustable valve gear, the amount of overlap of an exhaust air bulb open period and an intake valve open period is expanded, and there is a thing to which the amount of internals EGR is made to increase. In this case, it is desirable to perform control which amends ignition timing, fuel oil consumption, bulb closing motion timing, etc. according to the amount of internals EGR.

[0003]

Moreover, in the patent reference 1, the basic value of the amount of internals EGR is computed from the service conditions (a load, an engine speed, an air-fuel ratio, an EGR rate, depression at engine manifold, etc.) of the engine at the time of overlap nothing, and amending the amount of internals EGR according to the variation of the service condition at the time of overlap is indicated.

[0004]

**[Patent reference 1]**

JP,2001-221105,A

[0005]

**[Problem(s) to be Solved by the Invention]**

However, it was difficult to presume the amount of internals EGR uniquely with the amount of overlap because operational status changes and combination, such as a load, an engine speed, a combustion air-fuel ratio, and a depression at engine manifold, changes.

Moreover, the patent reference 1 was not enough as the precision of the amount of internals EGR computed by change of each parameter, when amending the amount of internals EGR from the variation of a service condition.

[0006]

It is made in order that this invention may solve the above-mentioned problem, and it aims at presuming the amount of internals EGR with a sufficient precision according to an engine's service condition.

[0007]

**[Means for Solving the Problem]**

Therefore, in this invention, whenever [ cylinder internal temperature / at the time of exhaust air bulb clausilium ], the cylinder internal pressure at the time of exhaust air bulb clausilium and the gas constant of the exhaust gas presentation according to a combustion air-fuel ratio are computed respectively, and the capacity in a cylinder at the time of exhaust air bulb clausilium is computed based on these at least. And it blows under overlap of an exhaust air bulb open period and an intake valve open period, and capacity is computed. And it blows with the capacity in a cylinder and the amount of internals EGR is computed based on capacity.

[0008]

**[Effect of the Invention]**

According to this invention, it is not concerned with a service condition but the amount of internal EGR can be presumed with a sufficient precision based on the quantity of state inside the cylinder after a burn out (gas constant of temperature, a pressure, and exhaust gas).

[0009]

[Embodiment of the Invention]

Hereafter, the operation gestalt of this invention is explained based on a drawing.

Drawing 1 is system configuration drawing of an internal combustion engine's amount presumption equipment of internal EGR.

The combustion chamber 3 formed by the piston 2 of each cylinder of an engine 1 is equipped with the intake valve 5 and the exhaust air bulb 6 so that an ignition plug 4 may be surrounded. The lift property (closing motion stage) of an intake valve 5 and the exhaust air bulb 6 is changing the phase of the cam to a cam shaft by the adjustable valve train solenoids 22 and 23 prepared in the inspired air flow path and the exhaust side, and control of valve timing is possible for it.

[0010]

The electronics control throttle valve 19 is formed in the inhalation-of-air path 7, and, thereby, inhalation new air volume is controlled. Supply of a fuel is made by the injector 20 formed in the inhalation-of-air path 7 for every cylinder (or each combustion chamber 3 is attended directly -- making). Gaseous mixture is lit by the ignition plug 4 in a combustion chamber 3, and it burns, and is discharged to a flueway 8.

Here, actuation of the electronics control throttle valve 19, an injector 20, an ignition plug 4 (ignition coil 21 with built-in PAWATORA), and the adjustable valve train solenoids 22 and 23 is controlled by the engine control unit (ECU) 30.

[0011]

The signal from various sensors is inputted into ECU30 for these control.

The crank angle sensor 14 outputs a crank angle signal synchronizing with an engine revolution, and, thereby, can detect an engine speed with a crank angle location. And the cam angle sensors 16 and 17 can detect the cam angle of an intake valve 5 and the exhaust air bulb 6, and, thereby, can detect the operating state of the adjustable valve train solenoids 22 and 23.

[0012]

and At the inhalation-of-air path 7 inhalation new air volume The air flow meter 9 to detect, the MAP sensor 10 which detects a MAP on electronics control throttle-valve 19 lower stream of a river, the exhaust-gas-pressure sensor 11 which detects exhaust gas pressure in a flueway 7, the exhaust-gas-temperature sensor 12 which detects an exhaust-gas temperature in a flueway 8, and the amount of oxygen contained during exhaust air in a flueway 8 The output signal of O2 sensor (oxygen sensor) 13 to detect, the coolant temperature sensor 15 which detects the circulating water temperature of an engine 1, and the accelerator opening sensor 18 which detects an accelerator opening is also inputted into ECU30, and these conditions can be detected.

[0013]

Next, presumption of the amount of internal EGR which ECU30 performs, and the rate of internal EGR is explained below. Drawing 2 - drawing 7 are control block diagrams, drawing 8 - drawing 16 </A> are control flow charts, and drawing 17 - drawing 2222 are tables which calculate each value.

Calculation of the rate MRESFR of internal EGR is explained using the control block diagram of the rate calculation means of internal EGR of drawing 2 , and the rate MRESFR calculation flow of internal EGR of drawing 8 .

[0014]

As for the inhalation new-air-volume calculation means shown in drawing 2 , the target combustion equivalent ratio TFBYA and the amount calculation means of internal EGR compute the amount MRES of internal EGR, respectively, as for the inhalation new air volume (the amount of new dispositions) MACYL, and a target combustion equivalent ratio calculation means, and the rate calculation means of internal EGR computes the rate MRESFR of internal EGR based on these calculation values.

At step 1 of drawing 8 , the inhalation new air volume MACYL per cylinder is computed based on the inhalation new air volume measured by the air flow meter 9.

[0015]

At step 2, the target combustion equivalent ratio TFBYA decided according to the engine speed detected based on the signal of the crank angle sensor 14, the accelerator opening detected based on the signal of the accelerator opening sensor 18, and the circulating water temperature detected based on the signal of a coolant temperature sensor 15 is computed.

In addition, if theoretical air fuel ratio is set to 14.7, the target combustion equivalent ratio TFBYA is expressed by the degree type from a target combustion air-fuel ratio, and when a target combustion air-fuel ratio is SUTOIKI, it will be set to 1.

[0016]

$TFBYA=14.7/\text{target combustion air-fuel ratio} \dots (1)$

At step 3, the amount MRES of internals EGR per cylinder is computed according to the flow chart of drawing 9 mentioned later.

At step 4, the rate MRESFR of internal EGR (the amount of internals EGR to the total capacity per cylinder comparatively) is computed by the degree type, and processing is ended.

[0017]

$MRESFR=MRES/\{MRES+MACYLx (1+TFBYA/14.7)\} \dots (2)$

Here, calculation of the amount MRES of internals EGR of step 3 is explained using the control block diagram of the amount calculation means of internals EGR of drawing 3, and the amount calculation flow of internals EGR of drawing 9.

[0018]

The capacity calculation means in a cylinder is blown during the overlap (it is indicated in drawing as "O/L") of capacity MRESCYL in a cylinder, an intake valve 5, and the exhaust air bulb 6 at the time of the exhaust air bulb clausilium shown in drawing 3 (it is indicated in drawing as "the time of EVC"), a capacity calculation means is blown, capacity MRESOL is computed, respectively, and the amount calculation means of internals EGR computes the amount MRES of internals EGR based on these calculation values.

[0019]

At step 5 of drawing 9, capacity MRESCYL in a cylinder is computed according to the flow chart of drawing 10 mentioned later at the time of the exhaust air bulb clausilium which is the capacity which remains inside a cylinder at the time of exhaust air bulb clausilium.

At step 6, according to the flow chart of drawing 11 mentioned later, it blows during the overlap which is the capacity blown from an exhaust side to an inspired air flow path during overlap, and capacity MRESOL is computed.

[0020]

At step 7, it blows during capacity MRESCYL in a cylinder, and overlap at the time of exhaust air bulb clausilium, capacity MRESOL is added, and the amount MRES of internals EGR is computed by the degree type.

$MRES=MRESCYL+MRESOL \dots (3)$

Here, calculation of capacity MRESCYL in a cylinder is explained to be the control block diagram of the capacity calculation means in a cylinder using the capacity MRESCYL calculation flow in a cylinder at the time of the exhaust air bulb clausilium of drawing 10 at the time of the exhaust air bulb clausilium of drawing 4 at the time of the exhaust air bulb clausilium of step 5.

[0021]

The target combustion equivalent ratio calculation means shown in drawing 4 computes the target combustion equivalent ratio TFBYA of exhaust gas, and an exhaust gas gas constant calculation means computes gas constant REX based on this value. In a calculation means, a pressure calculation means computes [ a cylinder content volume calculation means / whenever / cylinder internal temperature ] the cylinder internal pressure PEVC whenever [ cylinder internal temperature ], respectively at the time of TEVC and exhaust air bulb clausilium at the time of the cylinder content volume VEVC and exhaust air bulb clausilium at the time of exhaust air bulb clausilium. And based on these calculation values, the capacity calculation means in a cylinder computes capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium.

[0022]

At step 8 of drawing 10, it asks for the cylinder content volume VEVC from the table shown in drawing 17 at the time of exhaust air bulb clausilium. Drawing 17 is a cylinder content volume VEVC calculation table at the time of exhaust air bulb clausilium, an axis of abscissa shows the exhaust air bulb closing motion timing variation VTCNOWE, and the axis of ordinate shows the cylinder content volume VEVC at the time of exhaust air bulb clausilium.

Here, in the engine which has the device in which an exhaust air bulb clausilium stage is changed, it asks for the cylinder content volume VEVC from a table according to the exhaust air bulb closing motion timing variation VTCNOWE detected based on the signal of the cam angle sensor 17 of an exhaust side at the time of the exhaust air bulb clausilium shown in drawing 17.

[0023]

In addition, in the engine which has the device in which a compression ratio is changed, it asks for the cylinder content volume VEVC from a table at the time of the exhaust air bulb clausilium according to the variation of a compression ratio.

Moreover, in the engine which has the device which makes adjustable simultaneously an exhaust air bulb clausilium stage and a compression ratio, it asks for the cylinder content volume VEVC from a table at the time of the exhaust air bulb clausilium according to an exhaust air bulb clausilium stage and compression ratio variation.

[0024]

At step 9 of drawing 10, gas constant REX of exhaust gas according to the target combustion equivalent ratio TFBYA is calculated from the table shown in drawing 18. Drawing 18 is an exhaust gas gas constant REX calculation table, an axis of abscissa shows the target combustion equivalent ratio TFBYA, and the axis of ordinate shows gas constant REX of exhaust gas. In addition, the dotted line in drawing 18 shows SUTOIKI.

At step 10, TEVC is presumed whenever [ cylinder internal temperature ] based on the exhaust-gas temperature detected based on the signal of the exhaust-gas-temperature sensor 12 at the time of exhaust air bulb clausilium. In addition, at the time of exhaust air bulb clausilium, whenever [ cylinder internal temperature ], since TEVC changes with the heating values according to the fuel oil consumption of an injector 20, it may be calculated from the table using such a property.

[0025]

At step 11, the cylinder internal pressure PEVC is presumed based on the exhaust gas pressure detected based on the signal of the exhaust-gas-pressure sensor 11 at the time of exhaust air bulb clausilium. In addition, at the time of exhaust air bulb clausilium, since the cylinder internal pressure PEVC is decided by the gaseous mixture product and tubing internal resistance of an exhaust air system, you may ask for it from the table according to a gaseous mixture product flow rate.

At step 12, capacity MRESCYL in a cylinder is computed by the degree type from the calculation value of the cylinder internal pressure PEVC whenever [ cylinder internal temperature ] at the time of the exhaust air bulb clausilium which remains inside a cylinder at the time of exhaust air bulb clausilium at the time of TEVC and exhaust air bulb clausilium at the time of the cylinder content volume VEVC, exhaust gas gas constant REX, and exhaust air bulb clausilium at the time of the exhaust air bulb clausilium computed in step 8 - step 11.

[0026]

$MRESCYL = (PEVC \times VEVC) / (REX \times TEVC) \dots (4)$

Here, it blows during the overlap of drawing 5, and blows during the control block diagram of capacity calculation, and the overlap of drawing 11, and calculation of capacity MRESOL blown from an exhaust side to an inspired air flow path during the overlap of step 6 of drawing 9 is explained using a capacity MRESOL calculation flow.

[0027]

The closing motion timing variation calculation means of the exhaust air bulb and intake valve which are shown in drawing 5 computes the overlap variation VTCOL from the closing motion timing variation VTCNOW and VTCNOWE of an intake valve and an exhaust air bulb, and an addition effective-area calculation means computes the addition effective area ASUMOL during overlap based on this calculation value. A target combustion equivalent ratio calculation means computes equivalent ratio TFBYA, and an exhaust gas gas constant calculation means computes gas constant REX based on this calculation value. And based on these calculation values, and an engine-speed calculation means, an exhaust gas ratio-of-specific-beat calculation means and each calculation value according whenever [ cylinder internal temperature ] to a cylinder internal pressure calculation means, a MAP calculation means, and a choke supercharge judging calculation means the time of a calculation means and exhaust air bulb clausilium the time of exhaust air bulb clausilium, it blows during overlap, and a capacity calculation means is blown and computes capacity MRESOL.

[0028]

At step 13 of drawing 11, the overlap variation VTCOL is computed by the degree type from the intake valve closing motion timing variation VTCNOW detected based on the signal of the cam angle sensor 16 which detects the phase of an inspired air flow path cam, and the exhaust air bulb closing motion timing variation VTCNOWE detected based on the signal of the cam angle sensor 17 which detects the phase of an exhaust side cam.

[0029]

VTCOL=VTCNOW+VTCNOWE ... (5)

At step 14, it asks for the addition effective area ASUMOL under overlap from the table shown in drawing 19  $R > 9$  according to the overlap variation VTCOL computed by (5) formulas. Drawing 19 is a table which computes the addition effective area under overlap, an axis of abscissa shows the overlap variation VTCOL, and the axis of ordinate shows the addition effective area ASUMOL under overlap. If the overlap variation VTCOL becomes large, the addition effective area ASUMOL will become large.

[0030]

Here, drawing 20 is the explanatory view of the addition effective area ASUMOL under overlap, and, as for the axis of abscissa, the axis of ordinate shows each opening area of an intake valve 5 and the exhaust air bulb 6 whenever [ crank angle ]. And effective opening area at a certain event under overlap is made into the smaller one among exhaust air bulb opening area and intake valve opening area. That is, the addition effective area ASUMOL during the whole term under overlap is shown as an integral value (slash section in drawing) of the period which the intake valve 5 and the exhaust air bulb 6 are opening.

[0031]

Thus, by computing the addition effective area ASUMOL during overlap, false [ of the amount of overlap of an intake valve 5 and the exhaust air bulb 6 ] can be carried out with one orifice (runoff hole), and the flow rate which passes this orifice from the condition of an exhaust air system and the condition of an inhalation-of-air system is computed in simple.

At step 15 of drawing 11, engine-speed NRPM is computed based on the signal of the crank angle sensor 14.

[0032]

At step 16, the exhaust gas ratio of specific beat SHEATR is computed from the map shown in drawing 21. This control configuration is shown in drawing 6.

As for the target combustion equivalent ratio calculation means shown in drawing 6, a calculation means computes [ whenever / cylinder internal temperature ] TEVC whenever [ cylinder internal temperature ], respectively at the time of the target combustion equivalent ratio TFBYA and exhaust air bulb clausilium, and an exhaust gas ratio-of-specific-beat calculation means computes the exhaust gas ratio of specific beat SHEATR based on these calculation values.

[0033]

Drawing 21 is an exhaust gas ratio-of-specific-beat calculation map, an axis of abscissa shows the target combustion equivalent ratio TFBYA, and the axis of ordinate shows the exhaust gas ratio of specific beat SHEATR. In addition, if the exhaust gas ratio of specific beat SHEATR becomes small and is on the rich or Lean side when the dotted line in drawing shows the location of SUTOIKI and the target combustion equivalent ratio TFBYA is near SUTOIKI, the ratio of specific beat SHEATR will become large. And a thick wire arrow head shows the case where TEVC changes whenever [ cylinder internal temperature / at the time of exhaust air bulb clausilium ]. Here, according to TEVC, it asks for the exhaust gas ratio of specific beat SHEATR whenever [ cylinder internal temperature ] at the time of the exhaust air bulb clausilium computed at step 10 of the target combustion equivalent ratio TFBYA computed at step 2 of drawing 8, and drawing 10.

[0034]

At step 17, the control block diagram of a supercharge and a choke judging means of drawing 7 to mention later, and supercharge judging TBCRG and the choke judging CHOKE flow of drawing 12 perform the supercharge judging TBCRG and the choke judging CHOKE.

At step 18, whether the supercharge judging flag TBCRG in step 17 being 0 and a supercharge condition are judged. When the supercharge judging flag TBCRG is 0, it progresses to step 19, and when the supercharge judging flag TBCRG is not 0, it progresses to step 22.

[0035]

At step 19, whether the choke judging flag CHOKE in step 17 being 0 and a choke condition are judged. When the choke judging flag CHOKE is 0, average \*\*\*\* return quantity-of-gas-flow MRESOLtmp under having no supercharge and overlap at the time of choke nothing is computed from the flow of drawing 13 which progresses to step 20 and is mentioned later.

[0036]

On the other hand, at step 19, when the choke judging flag CHOKE in step 17 is not 0, from the flow of drawing 14 which progresses to step 21 and is mentioned later, it blows under having no supercharge and overlap at the time of those with a choke, and quantity-of-gas-flow MRESOLtmp is computed.

Moreover, at step 18, the supercharge judging flag TBCRG in step 17 is 1, i.e., a supercharge condition, and average \*\*\*\* return quantity-of-gas-flow MRESOLtmp under overlap at the time of those with supercharge and choke nothing is computed from the flow of drawing 15 which progresses to step 23 and is later mentioned when the choke judging flag CHOKE is 0 at step 22.

[0037]

On the other hand, at step 22, when the choke judging flag CHOKE in step 17 is 1, from the flow of drawing 16 which progresses to step 24 and is mentioned later, it blows at the time of those with those with supercharge, and a choke, and quantity-of-gas-flow MRESOLtmp is computed.

It progresses to step 25, after blowing at steps 20, 21, 23, and 24 and computing quantity-of-gas-flow MRESOLtmp.

[0038]

In blowing and integrating the addition effective area ASUMOL in quantity-of-gas-flow MRESOLtmp and an overlap period at step 25, according to the condition of the existence of supercharge, and the existence of a choke, it blows under overlap and capacity MRESOL is computed by the degree type.

$MRESOL = (MRESOLtmp \times ASUMOL \times 60) / (NRPM \times 360) \dots (7)$

Here, the supercharge and choke judging in step 17 are explained using the control block diagram of the supercharge and choke judging means of drawing 7, and supercharge judging TBCRG and the choke judging CHOKE flow of drawing 12.

[0039]

Based on each calculation value of a cylinder internal pressure calculation means and a MAP calculation means, supercharge and a choke judging means perform the supercharge judging TBCRG and the choke judging CHOKE at the time of an exhaust gas ratio-of-specific-beat calculation means and exhaust air bulb clausilium as shown in drawing 7.

At step 26 of drawing 12, the ratio PINBYEX with the cylinder internal pressure PEVC, i.e., an inhalation-of-air exhaust-gas-pressure ratio, is computed by the degree type at the time of the exhaust air bulb clausilium computed at step 11 of MAP PIN detected based on the signal of the MAP sensor 10, and drawing 10.

[0040]

$PINBYEX = PIN / PEVC \dots (8)$

At step 27, whether the inhalation-of-air exhaust-gas-pressure ratio's PINBYEX being one or less and a supercharge condition are judged.

When the inhalation-of-air exhaust-gas-pressure ratio PINBYEX is one or less (i.e., when you have no supercharge), it progresses to step 28, and supercharge judging flag TBCRG=0 is set as 0, and it progresses to step 31.

[0041]

the air searched for on the other hand from the table showing the exhaust gas ratio of specific beat SHEATR which it progressed to step 29 in with supercharge, set the supercharge judging flag TBCRG as 1, progressed to step 30, and was computed at step 16 of drawing 1111 in drawing 22 when the inhalation-of-air exhaust-gas-pressure ratio PINBYEX was larger than 1, and the gaseous mixture of a fuel -- it considers as the ratio of specific beat MIXAIRSHR.

[0042]

drawing 22 -- gaseous mixture -- a ratio-of-specific-beat MIXAIRSHR calculation table -- it is -- an axis of abscissa -- the target combustion equivalent ratio TFBYA and an axis of ordinate -- gaseous mixture -- the ratio of specific beat MIXAIRSHR is shown. In addition, the dotted line in drawing shows SUTOIKI, and the ratio of specific beat MIXAIRSHR is large at the time of the Lean side, and it becomes small at the time of a rich side. and the gaseous mixture corresponding to the target combustion equivalent ratio TFBYA computed at step 2 of drawing 2 -- it asks for the ratio of specific beat MIXAIRSHR from a table.

[0043]

and the step 30 -- setting -- the exhaust gas ratio of specific beat SHEATR -- gaseous mixture -- the ratio of specific beat of the gas which passes an orifice by transposing to the ratio of specific beat MIXAIRSHR when the gas flow under overlap at the time of supercharge of a turbo charger, inertia supercharging, etc. goes to an exhaust air system from an inhalation-of-air system (it blows) -- the inhalation of air from the ratio of specific beat of exhaust gas -- by changing into the ratio of specific beat of gaseous mixture, the capacity to blow is presumed with a sufficient precision and the amount of internals EGR is computed with a sufficient precision.

[0044]

At step 31, choke judging threshold SLCHOKEL of min and max and SLCHOKEH are computed by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 or step 30.

$$SLCHOKEL = \{2/(SHEATR+1)\}^{\wedge} \{SHEATR/(SHEATR-1)\} \dots (9a)$$

$$SLCHOKEH = \{2/(SHEATR+1)\}^{\wedge} \{-SHEATR/(SHEATR-1)\} \dots (9b)$$

This choke judging threshold SLCHOKEL and SLCHOKEH are computing the threshold value which carries out a choke.

[0045]

Moreover, in step 31, on a control configuration, when power count is difficult, beforehand, (9a) and the count result of a formula (9b) are memorized as a minimum choke judging threshold SLCHOKEL table and a maximum choke judging threshold SLCHOKEH table, and may be searched for according to the exhaust gas ratio of specific beat SHEATR.

At step 32, the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 is more than minimum choke judging threshold SLCHOKEL, and whether it being in within the limits below maximum choke judging threshold SLCHOKEH and a choke condition are judged.

[0046]

When the inhalation-of-air exhaust-gas-pressure ratio PINBYEX is in within the limits (i.e., when it judges that he has no choke), it progresses to step 33 and the choke judging flag CHOKE is set as 0.

On the other hand, when there is no inhalation-of-air exhaust-gas-pressure ratio PINBYEX in within the limits (i.e., when it is judged as those with a choke), it progresses to step 34 and the choke judging flag CHOKE is set as 1.

[0047]

Moreover, step 20 of drawing 11 blows, it blows during overlap at the time of having-no supercharge of drawing 1313, and choke nothing, and calculation of quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.

At step 35, the quantity-of-gas-flow formula consistency term MRSOLD is computed by the degree type based on TEVC whenever [ cylinder internal temperature / at the time of gas constant REX of the exhaust gas computed at step 9 of drawing 10, and the exhaust air bulb clausilium computed at step 10 ].

[0048]

$$MRSOLD = \text{SQRT} \{1/(REX \times TEVC)\} \dots (10)$$

Here, SQRT is a multiplier about temperature and a gas constant. In addition, on a control configuration, when calculation of the quantity-of-gas-flow formula consistency term MRSOLD is difficult, beforehand, the count result of (10) types is memorized as a map, and you may ask according to TEVC whenever [ exhaust gas gas constant REX and cylinder internal temperature ].

[0049]

At step 36, the quantity-of-gas-flow formula pressure-differential term MRSOLP is computed by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 of drawing 11, and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 of drawing 12.

$$MRSOLP = \text{SQRT} [SHEATR/(SHEATR-1) \times \{PINBYEX^{\wedge}(2/-SHEATR) - PINBYEX^{\wedge}(SHEATR+1) / (SHEATR)\}] \dots (11)$$

At step 37, based on the quantity-of-gas-flow formula consistency term MRSOLD and the quantity-of-gas-flow formula pressure-differential term MRSOLP which were computed at the cylinder internal pressure PEVC, step 35 of drawing 13, and step 36 at the time of the exhaust air bulb clausilium computed at step 11 of drawing 10, it blows under overlap at the time of supercharge-less - choke nothing, and a flow rate MRESOLtmp is computed by the degree type.

[0050]

$$MRESOLtmp = 1.4 \times PEVC \times MRSOLD \times MRSOLP \dots (12)$$

Moreover, step 21 blows, it blows at the time of having no supercharge of drawing 14, and those with a choke, and quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.

[0051]

At step 38, the quantity-of-gas-flow formula consistency term MRSOLD is computed from the above-mentioned (10) types as well as step 35 of drawing 13.

At step 39, the pressure-differential term MRSOLPC is searched for by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 16 of drawing 11 at the time of a quantity-of-gas-flow formula choke.

[0052]

$$MRSOLPC = \text{SQRT} [SHEATR \times \{2/(SHEATR+1)\}^{\wedge} \{(SHEATR+1) / (SHEATR-1)\}] \dots (13)$$

In addition, on a control configuration, when power count is difficult, beforehand, the count result of (13) types is memorized as a pressure-differential term MRSOLPC map at the time of a quantity-of-gas-flow formula choke, and may be searched for according to the exhaust gas ratio of specific beat SHEATR. [0053]

At the time of the choke computed at the quantity-of-gas-flow formula consistency term MRSOLD computed at step 38 of the cylinder internal pressure PEVC and drawing 14 at the time of the exhaust air bulb clausilium computed at step 11 of drawing 10, and step 39, based on the pressure-differential term MRSOLPC, it blows during the overlap at the time of those with supercharge-less - choke, and a flow rate MRESOLtmp is computed by the degree type at step 40.

[0054]

$MRESOLtmp = PEVCxMRSOLDxMRSOLPC \dots (14)$

Moreover, it blows at the time of those with supercharge, and choke [ of drawing 15 ] nothing, and calculation of average \*\*\*\* return quantity-of-gas-flow MRESOLtmp under overlap of step 23 is explained using a quantity-of-gas-flow calculation flow.

[0055]

At step 41, the pressure-differential term MRSOLPT is searched for by the degree type based on the exhaust gas ratio of specific beat SHEATR computed at step 30 of drawing 12, and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX computed at step 26 at the time of quantity-of-gas-flow formula supercharge.  $MRSOLPT = \text{SQRT} [ \text{SHEATR} / (\text{SHEATR}-1) \times \{ \text{PINBYEX}^{(-2/\text{SHEATR})} - \text{PINBYEX}^{(-(\text{SHEATR}+1)/\text{SHEATR})} \} ] \dots (15)$

In addition, constitutionally, when [ of control ] power count is difficult, beforehand, the count result of (15) types is memorized as a pressure-differential term MRSOLPT map at the time of quantity-of-gas-flow formula supercharge, and may be searched for according to the exhaust gas ratio of specific beat SHEATR and the inhalation-of-air exhaust-gas-pressure ratio PINBYEX.

[0056]

At the time of MAP PIN detected based on the signal of the MAP sensor 10, and the supercharge computed at step 41, based on the pressure-differential term MRSOLPT, it blows during overlap at the time of those with supercharge, and choke nothing, and quantity-of-gas-flow MRESOLtmp is computed by the degree type at step 42.

$MRESOLtmp = -0.152xPINxMRSOLPT \dots (16)$

Here, it blows, and quantity-of-gas-flow MRESOLtmp can express the quantity of gas flow which blows from an inhalation-of-air system to an exhaust air system during overlap with a negative value being shown, and reduces the amount of internals EGR by it based on this.

[0057]

Moreover, step 24 blows, it blows during overlap at the time of those with supercharge and those with a choke of drawing 16, and calculation of quantity-of-gas-flow MRESOLtmp is explained using a quantity-of-gas-flow calculation flow.

At step 43, the pressure-differential term MRSOLPC is searched for from (13) types or a map as well as step 39 of drawing 14 at the time of a quantity-of-gas-flow formula choke.

[0058]

At the time of MAP PIN and a quantity-of-gas-flow formula choke, based on the pressure-differential term MRSOLPC, it blows during the overlap at the time of those with supercharge, and those with a choke, and quantity-of-gas-flow MRESOLtmp is computed by the degree type at step 44.

$MRESOLtmp = -0.108xPINxMRSOLPC \dots (17)$

Here, it blows, and quantity-of-gas-flow MRESOLtmp can express the quantity of gas flow which blows from an inspired air flow path to an exhaust side during overlap with a negative value being shown, and will reduce the amount of internals EGR by it.

[0059]

Here, at steps 20, 21, 23, and 24, according to the condition of the existence of supercharge, and the existence of a choke, it blows and quantity-of-gas-flow MRESOLtmp is computed. And after blowing during overlap at the above-mentioned step 25 and computing capacity MRESOL, it progresses to step 7 from step 6 of drawing 9, and the amount MRES of internals EGR is computed at the above-mentioned step 7. And it progresses to step 4 from step 3 of drawing 8, the above-mentioned rate MRESFR of internal EGR is computed, and processing is ended.

[0060]

A means to compute TEVC whenever [ cylinder internal temperature / at the time of exhaust air bulb

clausilium] according to this operation gestalt (step 10), A means to compute the cylinder internal pressure PEVC at the time of exhaust air bulb clausilium (step 11), A means to compute gas constant REX of an exhaust gas presentation according to a combustion air-fuel ratio (step 9), A means to compute capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium based on TEVC, said cylinder internal pressure PEVC, and said gas constant REX whenever [ said cylinder internal temperature ] at least (step 12), It has a means (step 25) to blow under overlap of an exhaust air bulb open period and an intake valve open period, and to compute capacity MRESOL, and blows with capacity MRESCYL in a cylinder, and the amount MRES of internals EGR is computed based on capacity MRESOL (step 7). For this reason, based on the quantity of state inside the cylinder after a burn out (temperature TEVC, pressure PEVC, and gas constant REX), the amount MRES of internals EGR is computable from a physical formula. And it can respond to the consistency change by temperature and pressure variation, and the consistency change by change of the gas constant accompanying combustion air-fuel ratio change, and is not concerned with a service condition, but the amount MRES of internals EGR can be presumed with a sufficient precision. Since the quantity of state inside a cylinder changes every moment and the amount MRES of internals EGR is computable in transient operational status especially based on the changing quantity of state, the presumed precision of the amount MRES of internals EGR at the time of transient operation can be improved. And ignition timing, fuel oil consumption, bulb closing motion timing (the amount of overlap), etc. are appropriately controllable by presuming the amount MRES of internals EGR with a sufficient precision. Furthermore, since the amount MRES of internals EGR is computed based on a physical formula (three formulas) and each control value is determined based on this value MRES according to each parameter even if it is control construction containing a multi-dimension parameter, it can build easily.

[0061]

Moreover, according to this operation gestalt, it is constituted including a means (step 8) to compute the cylinder content volume VEVC at the time of exhaust air bulb clausilium further, and capacity MRESCYL in a cylinder at the time of exhaust air bulb clausilium is computed by the physical formula (four formulas) based on these calculation values. For this reason, in consideration of the cylinder content volume VEVC at the time of exhaust air bulb clausilium, the amount MRES of internals EGR is computable from a physical formula (three formulas) based on the quantity of state inside the cylinder after a burn out (volume VEVC, temperature TEVC, pressure PEVC, and gas constant REX). Also in this case, it can respond to the consistency change by temperature and pressure variation, and the consistency change by change of the gas constant accompanying combustion air-fuel ratio change, and is not concerned with a service condition, but the amount MRES of internals EGR can be presumed with a sufficient precision. Moreover, even if it is control construction containing a multi-dimension parameter, in order to compute the amount MRES of internals EGR based on a physical formula (three formulas) according to each parameter, it can build easily and adaptation becomes easy.

[0062]

Moreover, according to this operation gestalt, a cylinder content volume calculation means (step 8) calculates the cylinder content volume value VEVC geometrically decided from the piston location at the time of exhaust air bulb clausilium at the time of exhaust air bulb clausilium. For this reason, the cylinder content volume VEVC at the time of exhaust air bulb clausilium can be computed appropriately, and the more exact amount MRES of internals EGR can be calculated.

Moreover, according to this operation gestalt, a cylinder content volume calculation means (step 8) calculates the cylinder content volume value VEVC at the time of exhaust air bulb clausilium according to the variation in the engine which has the device in which the cylinder content volume of an exhaust air bulb clausilium stage and this stage is changed relatively at the time of exhaust air bulb clausilium. For this reason, even if it is the engine which has the device (adjustable bulb closing motion timing, adjustable compression ratio) in which the cylinder content volume VEVC changes at the time of exhaust air bulb clausilium, it can ask for the cylinder content volume VEVC easily, and the more exact amount MRES of internals EGR can be computed. And since each value is decided geometrically, it can compute easily and can develop efficiently by losing the need by system operation of making it suiting.

[0063]

Moreover, according to this operation gestalt, a gas constant calculation means (step 9) calculates gas constant REX corresponding to change of an exhaust gas presentation according to the target combustion equivalent ratio TFBYA ( drawing 18 ). For this reason, when there is consistency change accompanying the exhaust gas presentation change according to the target combustion equivalent ratio TFBYA (i.e., also when there is a change in the target combustion equivalent ratio TFBYA after a change in a full admission

operation region after Lean operation and start up), the amount MRES of internals EGR can be presumed with a sufficient precision. And gas constant REX can be computed from the reaction formula by a fuel presentation and air presentation, and can be efficiently developed by losing the need by system operation of making it suiting.

[0064]

According to this operation gestalt, it blows during overlap. Moreover, a capacity calculation means (step 25) A means to compute TEVC whenever [ cylinder internal temperature / at the time of exhaust air bulb clausilium ] (step 10), A means to compute the cylinder internal pressure PEVC at the time of exhaust air bulb clausilium (step 11), A means to compute gas constant REX corresponding to the exhaust gas presentation change according to a combustion air-fuel ratio (step 9), A means (step 10) to compute MAP PIN, and a means to compute the ratio of specific beat SHEATR corresponding to exhaust gas presentation change (step 14), A means to compute the addition effective area ASUMOL under overlap of an exhaust air bulb open period and an intake valve open period (step 14), It is constituted including a means (step 15) to compute the engine engine speed NRPM, and a means (steps 27 and 32) to judge the existence of supercharge and a choke, and blows under overlap based on these calculation values, and capacity MRESOL is computed. For this reason, based on the quantity of state under overlap (temperature TEVC, a pressure PEVC, gas constant REX, area ASUMOL), it blows by the physical formula (seven formulas), and capacity MRESOL can be computed with a sufficient precision. And it can respond to the consistency change and orifice passage volumetric flow rate change by change of a quantity of state, and blows with a sufficient precision during overlap in all operational status, and capacity MRESOL can be computed. Furthermore, also in the control construction containing a multi-dimension parameter, in order to compute the amount MRES of internals EGR based on a physical type (three formulas) according to each parameter, it can build easily and adaptation becomes easy.

[0065]

Moreover, according to this operation gestalt, based on the cylinder internal pressure PEVC, supercharge and the judgment means (steps 27 and 32) of a choke are equipped with a means (step 26) to compute the inhalation-of-air exhaust-gas-pressure ratio PINBYEX, and at the time of MAP PIN and exhaust air bulb clausilium, when a supercharge judging means (step 27) makes the ratio of specific beat SHEATR corresponding to exhaust gas presentation change those with supercharge, they set it up. For this reason, also in the time of inertia supercharging in full admission operation, and the supercharge by the supercharger, it blows under overlap with a sufficient precision, and capacity MRESOL can be computed. And even when a choke is generated in the time of idle operation etc., it blows with a sufficient precision and capacity MRESOL can be computed.

[0066]

moreover, a means ( drawing 20 ) to compute a means ( drawing 20 ) by which an addition effective-area calculation means (step 14) computes intake valve closing motion timing during overlap, and exhaust air bulb closing motion timing according to this operation gestalt -- since -- the amount of overlap is computed and it asks for the addition effective area ASUMOL according to this amount of overlap. For this reason, the addition effective area ASUMOL can be computed based on the amount of overlap, and count by the physical type (six formulas) can be simplified.

[0067]

Moreover, according to this operation gestalt, during overlap, an addition effective-area calculation means (step 14) integrates with either minimum value of the opening area in an inhalation-of-air valve lift, and the opening area in an exhaust air valve lift, and computes the addition effective area ASUMOL. For this reason, false [ of the addition effective area ASUMOL of an overlap period ] can be carried out as one orifice, and the flow rate which passes this orifice from the condition of an exhaust air system and the condition of an inhalation-of-air system can be computed in simple.

[Brief Description of the Drawings]

[Drawing 1] System configuration drawing of the amount presumption equipment of internals EGR

[Drawing 2] The control block diagram of the rate calculation means of internal EGR

[Drawing 3] The control block diagram of the amount calculation means of internals EGR

[Drawing 4] It is the control block diagram of the quantity-of-gas-flow calculation means in a cylinder at the time of exhaust air bulb clausilium.

[Drawing 5] It blows during overlap and is the control block diagram of a capacity calculation means.

[Drawing 6] The control block diagram of an exhaust gas ratio-of-specific-beat calculation means

[Drawing 7] The control block diagram of supercharge and a choke judging means

[Drawing 8] Rate calculation flow chart of internal EGR

[Drawing 9] The amount calculation flow chart of internals EGR

[Drawing 10] It is a capacity calculation flow chart in a cylinder at the time of exhaust air bulb clausilium.

[Drawing 11] It blows during overlap and is a capacity calculation flow chart.

[Drawing 12] A supercharge judging and a choke judging flow chart

[Drawing 13] It blows during overlap at the time of supercharge-less - choke nothing, and is a quantity-of-gas-flow calculation flow chart.

[Drawing 14] It blows during overlap at the time of those with supercharge-less - choke, and is a quantity-of-gas-flow calculation flow chart.

[Drawing 15] It blows during overlap at the time of those with supercharge, and choke nothing, and is a quantity-of-gas-flow calculation flow chart.

[Drawing 16] It blows during overlap at the time of those with supercharge, and those with a choke, and is a quantity-of-gas-flow calculation flow chart.

[Drawing 17] It is a cylinder content volume calculation table at the time of exhaust air bulb clausilium.

[Drawing 18] Exhaust gas gas constant calculation table

[Drawing 19] It is an addition effective-area calculation table during overlap.

[Drawing 20] It is the explanatory view of addition effective area during overlap.

[Drawing 21] Exhaust gas ratio-of-specific-beat calculation table

[Drawing 22] gaseous mixture -- a ratio-of-specific-beat calculation table

[Description of Notations]

1 Engine

5 Intake Valve

6 Exhaust Air Bulb

10 MAP Sensor

11 Exhaust-Gas-Pressure Sensor

12 Exhaust-gas-Temperature Sensor

13 O2 Sensor

14 Crank Angle Sensor

15 Coolant Temperature Sensor

16 Inspired Air Flow Path Cam Angle Sensor

17 Exhaust Side Cam Angle Sensor

18 Accelerator Opening Sensor

30 ECU

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[Translation done.]

**\* NOTICES \***

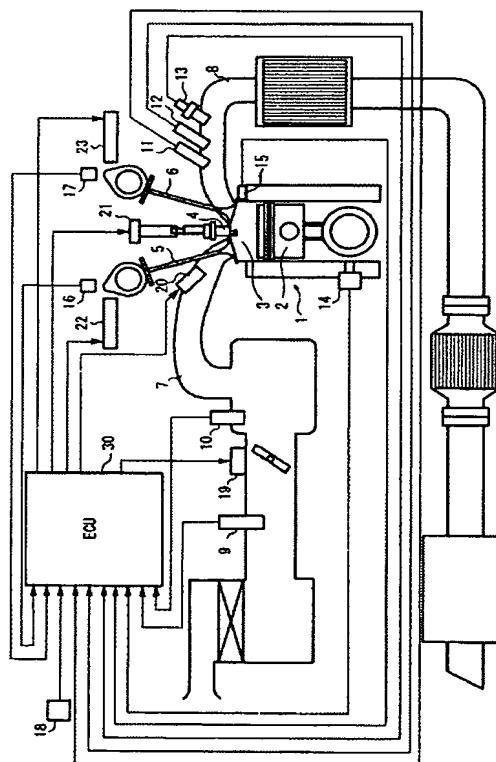
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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
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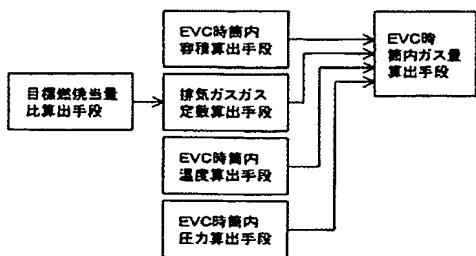
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**DRAWINGS**

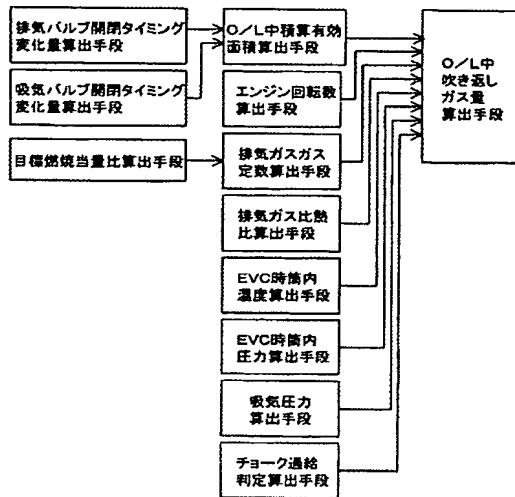
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**[Drawing 1]**

[Drawing 4]



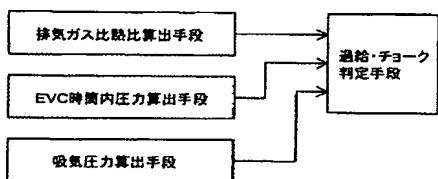
[Drawing 5]



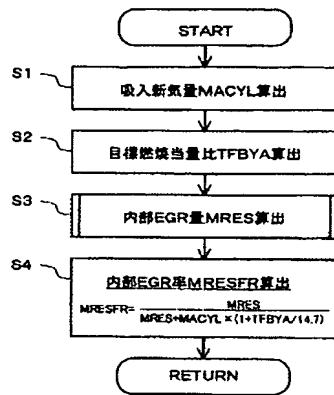
[Drawing 6]



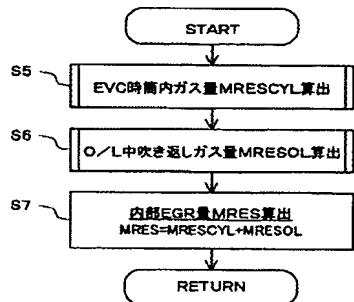
[Drawing 7]



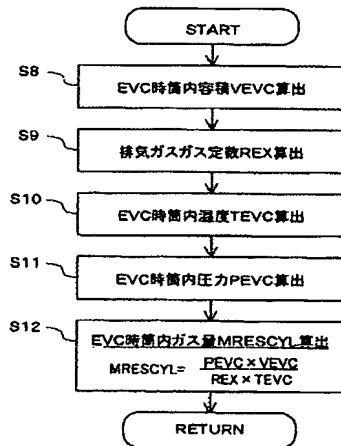
[Drawing 8]



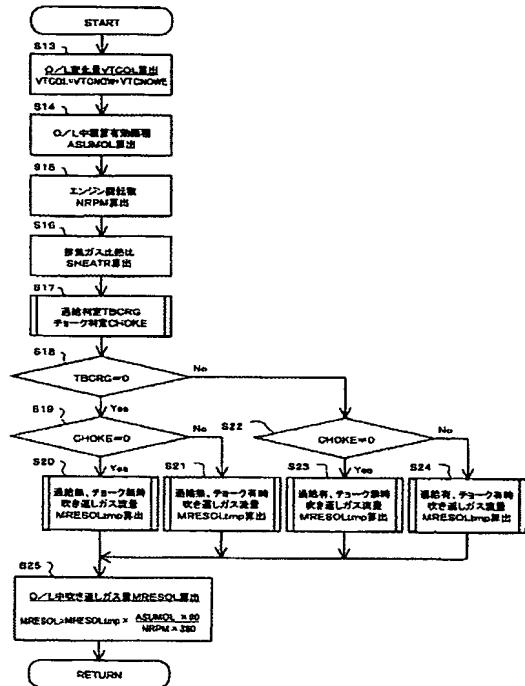
[Drawing 9]



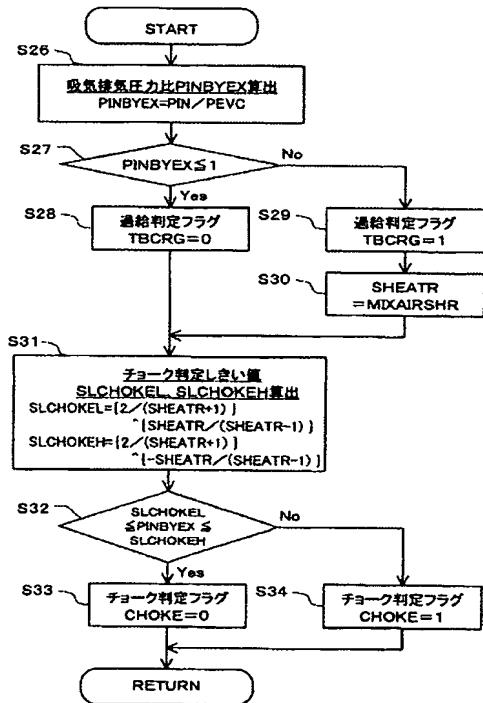
[Drawing 10]



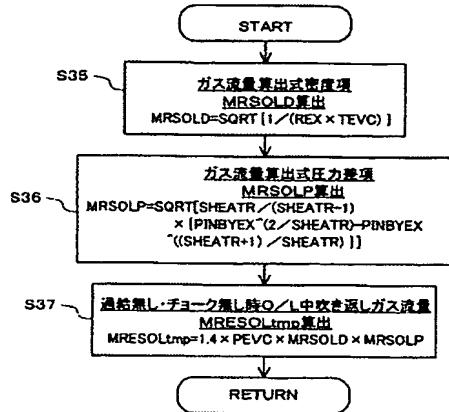
[Drawing 11]



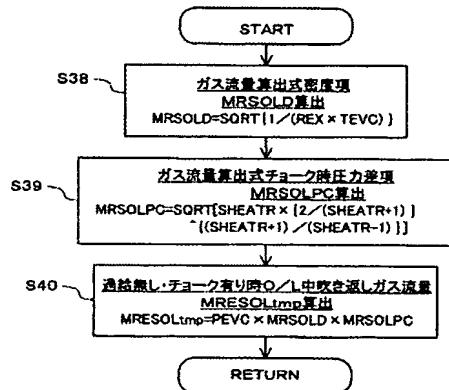
[Drawing 12]



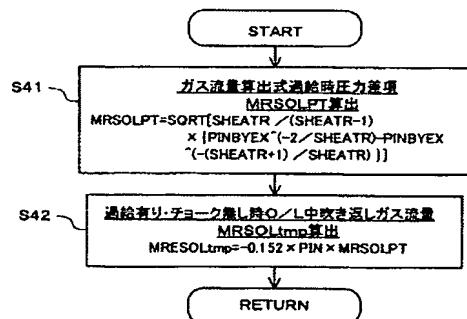
[Drawing 13]



[Drawing 14]



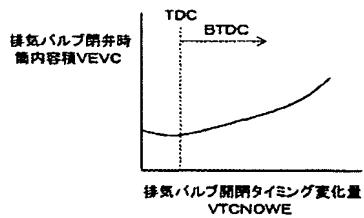
[Drawing 15]



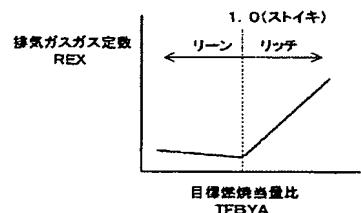
[Drawing 16]



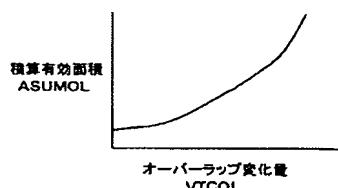
[Drawing 17]



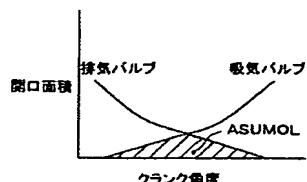
[Drawing 18]



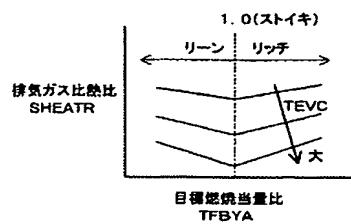
[Drawing 19]



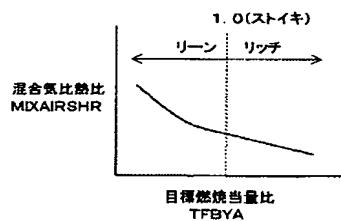
[Drawing 20]



## [Drawing 21]



## [Drawing 22]



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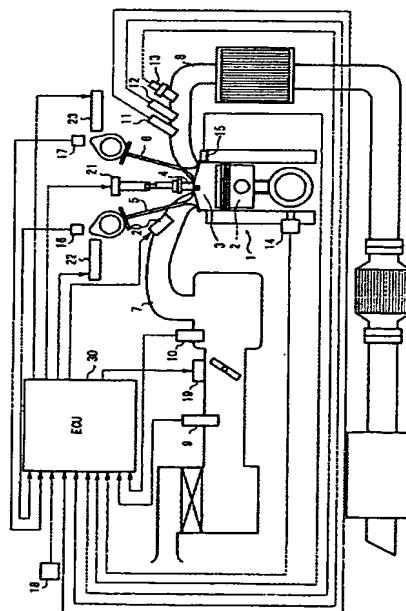
(54) 【発明の名称】 内燃機関の内部EGR量推定装置

## (57) 【要約】

【課題】機関のシリンダ内部の状態量から物理式に基づいて内部EGR量を精度良く推定する。

【解決手段】排気バルブ閉弁時において、排気温度センサ12、吸気圧力センサ10、排気圧力センサ11の信号に基づいて、筒内温度、筒内圧力を算出し、燃焼空燃比に応じた排気ガスのガス定数を算出し、筒内ガス量を算出する。そして、クランク角センサ14、水温センサ15、カム角センサ16、17、アクセル開度センサ18の信号に基づいて、吸気バルブ開期間及び排気バルブ開期間のオーバーラップ中の吹き返しガス量を算出する。そして、筒内ガス量と吹き返しガス量との算出値に基づいて、内部EGR量を算出する。

【選択図】 図1



**【特許請求の範囲】****【請求項 1】**

排気バルブ閉弁時の筒内温度を算出する手段と、  
 排気バルブ閉弁時の筒内圧力を算出する手段と、  
 燃焼空燃比に応じた排気ガス組成のガス定数を算出する手段と、  
 少なくとも前記筒内温度、前記筒内圧力、前記ガス定数に基づいて、排気バルブ閉弁時の筒内ガス量を算出する手段と、  
 排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量を算出する手段と、を備え、  
 前記筒内ガス量と前記吹き返しガス量とにに基づいて、内部EGR量を算出することを特徴 10  
 とする内燃機関の内部EGR量推定装置。

**【請求項 2】**

前記排気バルブ閉弁時筒内ガス量算出手段は、  
 排気バルブ閉弁時の筒内容積を算出する手段と、  
 前記排気バルブ閉弁時の筒内温度を算出する手段と、  
 前記排気バルブ閉弁時の筒内圧力を算出する手段と、  
 前記燃焼空燃比に応じた排気ガス組成のガス定数を算出する手段と、  
 を含んで構成され、これらの算出値に基づいて、物理式により排気バルブ閉弁時の筒内ガス量を算出することを特徴とする請求項 1 記載の内燃機関の内部EGR量推定装置。

**【請求項 3】**

前記排気バルブ閉弁時筒内容積算出手段は、排気バルブ閉弁時のピストン位置から幾何学的に決まる筒内容積値を求ることを特徴とする請求項 2 記載の内燃機関の内部EGR量推定装置。

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**【請求項 4】**

前記排気バルブ閉弁時筒内容積算出手段は、排気バルブ閉弁時期と該時期の筒内容積とを相対的に変化させる機構を有する機関においては、それらの変化量に応じて、排気バルブ閉弁時の筒内容積値を求ることを特徴とする請求項 2 記載の内燃機関の内部EGR量推定装置。

**【請求項 5】**

前記ガス定数算出手段は、目標燃焼当量比に応じ、排気ガス組成の変化に対応するガス定数を求ることを特徴とする請求項 1 ~ 請求項 4 のいずれか 1 つに記載の内燃機関の内部EGR量推定装置。

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**【請求項 6】**

前記オーバーラップ中吹き返しガス量算出手段は、  
 前記排気バルブ閉弁時の筒内温度を算出する手段と、  
 前記排気バルブ閉弁時の筒内圧力を算出する手段と、  
 前記燃焼空燃比に応じた排気ガス組成変化に対応したガス定数を算出する手段と、  
 吸気圧力を算出する手段と、  
 排気ガス組成変化に対応した比熱比を算出する手段と、  
 排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の積算有効面積を算出する手段と、  
 機関回転数を算出する手段と、  
 過給及びチョークの有無を判定する手段と、  
 を含んで構成され、これらの算出値に基づいて、オーバーラップ中の吹き返しガス量を算出することを特徴とする請求項 1 ~ 請求項 5 のいずれか 1 つに記載の内燃機関の内部EGR量推定装置。

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**【請求項 7】**

前記過給及びチョークの判定手段は、  
 前記吸気圧力と前記排気バルブ閉弁時筒内圧力とにに基づいて、吸気排気圧力比を算出する手段を備え、

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前記排気ガス組成変化に対応した比熱比を、前記過給判定手段が過給有りとした場合に設定することを特徴とする請求項 6 記載の内燃機関の内部 EGR 量推定装置。

【請求項 8】

前記オーバーラップ中積算有効面積算出手段は、  
吸気バルブ開閉タイミングを算出する手段と、  
排気バルブ開閉タイミングを算出する手段と、  
からオーバーラップ量を算出し、  
このオーバーラップ量に応じて有効面積の積算値を求める特徴とする請求項 6 または請求項 7 記載の内燃機関の内部 EGR 量推定装置。

【請求項 9】

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前記オーバーラップ中積算有効面積算出手段は、  
吸気バルブリフト中の開口面積と排気バルブリフト中の開口面積とのいずれか一方の最小値を積分して、積算有効面積を算出することを特徴とする請求項 6 または請求項 7 記載の内燃機関の内部 EGR 量推定装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

本発明は、内燃機関の内部 EGR 量（排出ガスの還流量）推定装置に関する。

【0002】

【従来の技術】

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従来から火花点火式内燃機関では、不活性成分増大化による燃焼温度抑制による NO<sub>x</sub>（窒素酸化物）の低減と、ポンブロスの低減による燃費低減とを図るために、可変動弁機構を利用して、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ量を拡大し、内部 EGR 量を増加させるものがある。この場合、内部 EGR 量に応じて、点火時期、燃料噴射量、バルブ開閉タイミングなどを補正する制御を行うことが望ましい。

【0003】

また、特許文献 1 には、オーバーラップ無し時の機関の運転条件（負荷・回転数・空燃比・EGR 率・吸気負圧など）から内部 EGR 量の基本値を算出し、オーバーラップ時の運転条件の変化量に応じて内部 EGR 量を補正することが開示されている。

【0004】

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【特許文献 1】

特開 2001-221105 号公報

【0005】

【発明が解決しようとする課題】

しかしながら、運転状態が変化し、負荷・回転数・燃焼空燃比・吸気負圧などの組み合わせが変化することで、オーバーラップ量により内部 EGR 量を一義的に推定することは困難であった。

また、特許文献 1 では、運転条件の変化量から内部 EGR 量を補正する場合には、各パラメータの変化により算出された内部 EGR 量の精度は十分なものではなかった。

【0006】

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本発明は上記問題を解決するためになされたものであり、機関の運転条件に応じて内部 EGR 量を精度良く推定することを目的とする。

【0007】

【課題を解決するための手段】

そのため本発明では、排気バルブ閉弁時の筒内温度、排気バルブ閉弁時の筒内圧力、燃焼空燃比に応じた排気ガス組成のガス定数を各々算出して、少なくともこれらに基づいて、排気バルブ閉弁時の筒内ガス量を算出する。そして、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量を算出する。そして、筒内ガス量と吹き返しガス量とに基づいて、内部 EGR 量を算出する。

【0008】

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**【発明の効果】**

本発明によれば、運転条件に関わらず、燃焼終了後のシリンダ内部の状態量（温度・圧力・排気ガスのガス定数）に基づき、精度良く内部EGR量を推定できる。

**【0009】****【発明の実施の形態】**

以下、図面に基づき本発明の実施形態について説明する。

図1は、内燃機関の内部EGR量推定装置のシステム構成図である。

エンジン1の各気筒のピストン2により画成される燃焼室3には、点火プラグ4を囲むように、吸気バルブ5と排気バルブ6とを備えている。吸気バルブ5及び排気バルブ6のリフト特性（開閉時期）は、吸気側及び排気側に設けられた可変動弁ソレノイド22, 23により、カム軸に対するカムの位相を変化させることで、バルブタイミングの制御が可能である。  
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**【0010】**

吸気通路7には、電子制御スロットル弁19が設けられており、これにより吸入新気量が制御される。燃料の供給は、吸気通路7に気筒毎に（または各燃焼室3に直接臨ませて）設けたインジェクタ20によりなされる。燃焼室3内で混合気は点火プラグ4により点火されて燃焼し、排気通路8へ排出される。

ここで、電子制御スロットル弁19、インジェクタ20、点火プラグ4（パワトラ内蔵点火コイル21）、可変動弁ソレノイド22, 23の作動は、エンジンコントロールユニット（ECU）30により制御される。  
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**【0011】**

これらの制御のため、ECU30には、各種センサからの信号が入力されている。

クランク角センサ14は、エンジン回転に同期してクランク角信号を出力し、これによりクランク角位置と共にエンジン回転数を検出可能である。そして、カム角センサ16, 17は、吸気バルブ5及び排気バルブ6のカム角を検出可能であり、これにより可変動弁ソレノイド22, 23の作動状態を検出可能である。

**【0012】**

そして、吸気通路7にて吸入新気量を検出するエアフローメータ9、電子制御スロットル弁19下流にて吸気圧力を検出する吸気圧力センサ10、排気通路7にて排気圧力を検出する排気圧力センサ11、排気通路8にて排気温度を検出する排気温度センサ12、排気通路8にて排気中に含まれる酸素量を検出するO2センサ（酸素センサ）13、エンジン1の冷却水温度を検出する水温センサ15、アクセル開度を検出するアクセル開度センサ18の出力信号もECU30に入力され、これらの状態を検出可能である。  
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**【0013】**

次に、ECU30が行う内部EGR量及び内部EGR率の推定について以下に説明する。図2～図7は制御構成図であり、図8～図16は制御フローチャートであり、図17～図22は各値を求めるテーブルである。

内部EGR率MRESFRの算出について、図2の内部EGR率算出手段の制御構成図と、図8の内部EGR率MRESFR算出フローとを用いて説明する。

**【0014】**

図2に示す吸入新気量算出手段は吸入新気量（新気質量）MACYL、目標燃焼当量比算出手段は目標燃焼当量比TFBYA、内部EGR量算出手段は内部EGR量MRESをそれぞれ算出し、これらの算出値に基づいて、内部EGR率算出手段は内部EGR率MRESFRを算出する。  
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図8のステップ1では、エアフローメータ9により計測された吸入新気量に基づいて1シリンダ当たりの吸入新気量MACYLを算出する。

**【0015】**

ステップ2では、クランク角センサ14の信号に基づいて検出されるエンジン回転数と、アクセル開度センサ18の信号に基づいて検出されるアクセル開度と、水温センサ15の信号に基づいて検出される冷却水温度とに応じて決まる目標燃焼当量比TFBYAを算出  
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する。

なお、目標燃焼当量比 TFBYA は、理論空燃比を 14.7 とすると、目標燃焼空燃比より次式により表され、目標燃焼空燃比がstoiキのときに 1 となる。

【0016】

$TFBYA = 14.7 / \text{目標燃焼空燃比} \dots (1)$

ステップ 3 では、後述する図 9 のフローチャートに従って、1 シリンダ当たりの内部 EGR 量 MRES を算出する。

ステップ 4 では、内部 EGR 率 MRESFR (1 シリンダ当たりの総ガス量に対する内部 EGR 量の割合) を次式により算出し、処理を終了する。

【0017】

$MRESFR = MRES / (MRES + MACYL \times (1 + TFBYA / 14.7)) \dots (2)$

ここで、ステップ 3 の内部 EGR 量 MRES の算出について、図 3 の内部 EGR 量算出手段の制御構成図と、図 9 の内部 EGR 量算出フローとを用いて説明する。

【0018】

図 3 に示す排気バルブ閉弁時 (図には「EV C 時」と示す) 筒内ガス量算出手段は筒内ガス量 MRESCYL、吸気バルブ 5 及び排気バルブ 6 のオーバーラップ (図には「O/L」と示す) 中吹き返しガス量算出手段は吹き返しガス量 MRESOL をそれぞれ算出し、これらの算出値に基づいて、内部 EGR 量算出手段は内部 EGR 量 MRES を算出する。

【0019】

図 9 のステップ 5 では、後述する図 10 のフローチャートに従って、排気バルブ閉弁時においてシリンダ内部に残留しているガス量である排気バルブ閉弁時筒内ガス量 MRESCYL を算出する。

ステップ 6 では、後述する図 11 のフローチャートに従って、オーバーラップ中に排気側から吸気側へ吹き返すガス量であるオーバーラップ中吹き返しガス量 MRESOL を算出する。

【0020】

ステップ 7 では、排気バルブ閉弁時筒内ガス量 MRESCYL とオーバーラップ中吹き返しガス量 MRESOL を加算して、内部 EGR 量 MRES を次式により算出する。

$MRES = MRESCYL + MRESOL \dots (3)$

ここで、ステップ 5 の排気バルブ閉弁時筒内ガス量 MRESCYL の算出について、図 4 の排気バルブ閉弁時筒内ガス量算出手段の制御構成図と、図 10 の排気バルブ閉弁時筒内ガス量 MRESCYL 算出フローとを用いて説明する。

【0021】

図 4 に示す目標燃焼当量比算出手段は排気ガスの目標燃焼当量比 TFBYA を算出し、この値に基づき、排気ガスガス定数算出手段はガス定数 RE X を算出する。排気バルブ閉弁時筒内容積算出手段は筒内容積 VEV C、排気バルブ閉弁時筒内温度算出手段は筒内温度 TEVC、排気バルブ閉弁時圧力算出手段は筒内圧力 PEVC をそれぞれ算出する。そして、これらの算出値に基づき、排気バルブ閉弁時筒内ガス量算出手段は筒内ガス量 MRESCYL を算出する。

【0022】

図 10 のステップ 8 では、図 17 に示すテーブルから排気バルブ閉弁時筒内容積 VEV C を求める。図 17 は、排気バルブ閉弁時筒内容積 VEV C 算出テーブルであり、横軸は排気バルブ閉弁タイミング変化量 VTCNOWE、縦軸は排気バルブ閉弁時筒内容積 VEV C を示している。

ここで、排気バルブ閉弁時期を変化させる機構を有するエンジンにおいては、排気側のカム角センサ 17 の信号に基づいて検出される排気バルブ閉弁タイミング変化量 VTCNOWE に応じて、図 17 に示す排気バルブ閉弁時筒内容積 VEV C をテーブルから求める。

【0023】

なお、圧縮比を変化させる機構を有するエンジンにおいては、圧縮比の変化量に応じた排

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気バルブ閉弁時筒内容積V E V Cをテーブルから求める。

また、排気バルブ閉弁時期と圧縮比とを同時に可変とする機構を有するエンジンにおいては、排気バルブ閉弁時期と圧縮比変化量とに応じた排気バルブ閉弁時筒内容積V E V Cをテーブルから求める。

【0024】

図10のステップ9では、図18に示すテーブルから目標燃焼当量比T F B Y Aに応じた排気ガスのガス定数R E Xを求める。図18は、排気ガスガス定数R E X算出テーブルであり、横軸は目標燃焼当量比T F B Y A、縦軸は排気ガスのガス定数R E Xを示している。なお、図18中の点線はストイキを示している。

ステップ10では、排気温度センサ12の信号に基づいて検出した排気温度に基づいて、<sup>10</sup>排気バルブ閉弁時筒内温度T E V Cを推定する。なお、排気バルブ閉弁時筒内温度T E V Cは、インジェクタ20の燃料噴射量に応じた熱量により変化するため、このような特性を利用したテーブルから求めてよい。

【0025】

ステップ11では、排気圧力センサ11の信号に基づいて検出された排気圧力に基づいて、排気バルブ閉弁時筒内圧力P E V Cを推定する。なお、排気バルブ閉弁時筒内圧力P E V Cは、混合気体積と排気系の管内抵抗とで決まるため、混合気体積流量に応じたテーブルから求めてよい。

ステップ12では、ステップ8～ステップ11において算出された排気バルブ閉弁時筒内容積V E V C、排気ガスガス定数R E X、排気バルブ閉弁時筒内温度T E V C、排気バルブ閉弁時筒内圧力P E V Cの算出値から、<sup>20</sup>排気バルブ閉弁時においてシリンダ内部に残留している排気バルブ閉弁時筒内ガス量M R E S C Y Lを次式により算出する。

【0026】

$$M R E S C Y L = (P E V C \times V E V C) / (R E X \times T E V C) \dots (4)$$

ここで、図9のステップ6のオーバーラップ中に排気側から吸気側へ吹き返すガス量M R E S O Lの算出について、図5のオーバーラップ中吹き返しガス量算出の制御構成図と、図11のオーバーラップ中吹き返しガス量M R E S O L算出フローとを用いて説明する。

【0027】

図5に示す排気バルブと吸気バルブとの開閉タイミング変化量算出手段は吸気バルブと排気バルブとの開閉タイミング変化量V T C N O W, V T C N O W Eからオーバーラップ変化量V T C O Lを算出し、この算出値に基づいて、オーバーラップ中積算有効面積算出手段は積算有効面積A S U M O Lを算出する。目標燃焼当量比算出手段は当量比T F B Y Aを算出し、この算出値に基づいて、排気ガスガス定数算出手段はガス定数R E Xを算出する。そして、これらの算出値と、エンジン回転数算出手段、排気ガス比熱比算出手段、排気バルブ閉弁時筒内温度算出手段、排気バルブ閉弁時筒内圧力算出手段、吸気圧力算出手段、チョーク過給判定算出手段による各算出値に基づいて、オーバーラップ中吹き返しガス量算出手段は吹き返しガス量M R E S O Lを算出する。

【0028】

図11のステップ13では、吸気側カムの位相を検出するカム角センサ16の信号に基づいて検出される吸気バルブ開閉タイミング変化量V T C N O Wと、排気側カムの位相を検出するカム角センサ17の信号に基づいて検出される排気バルブ開閉タイミング変化量V T C N O W Eとから、オーバーラップ変化量V T C O Lを次式により算出する。

【0029】

$$V T C O L = V T C N O W + V T C N O W E \dots (5)$$

ステップ14では、(5)式で算出したオーバーラップ変化量V T C O Lに応じて、図19に示すテーブルからオーバーラップ中の積算有効面積A S U M O Lを求める。図19は、オーバーラップ中の積算有効面積を算出するテーブルであり、横軸はオーバーラップ変化量V T C O L、縦軸はオーバーラップ中の積算有効面積A S U M O Lを示している。オーバーラップ変化量V T C O Lが大きくなると、積算有効面積A S U M O Lが大きくなる。

## 【0030】

ここで、図20は、オーバーラップ中の積算有効面積ASUMOLの説明図であり、横軸はクランク角度、縦軸は吸気バルブ5と排気バルブ6とのそれぞれの開口面積を示している。そして、オーバーラップ中の或る時点における有効な開口面積は、排気バルブ開口面積と吸気バルブ開口面積とのうち小さい方とする。すなわち、オーバーラップ中の全期間における積算有効面積ASUMOLは、吸気バルブ5及び排気バルブ6が開いている期間の積分値（図中の斜線部）として示される。

## 【0031】

このようにしてオーバーラップ中積算有効面積ASUMOLを算出することで、吸気バルブ5と排気バルブ6とのオーバーラップ量を1つのオリフィス（流出孔）と疑似でき、排 10 気系の状態と吸気系の状態とからこのオリフィスを通過する流量を簡略的に算出する。

図11のステップ15では、クランク角センサ14の信号に基づいてエンジン回転数N RPMを算出する。

## 【0032】

ステップ16では、図21に示すマップから排気ガス比熱比SHEATRを算出する。この制御構成は図6に示す。

図6に示す目標燃焼当量比算出手段は目標燃焼当量比TFBYA、排気バルブ閉弁時筒内温度算出手段は筒内温度TEVCをそれぞれ算出し、これらの算出値に基づき、排気ガス比熱比算出手段は排気ガス比熱比SHEATRを算出する。

## 【0033】

図21は、排気ガス比熱比算出マップであり、横軸は目標燃焼当量比TFBYA、縦軸は排気ガス比熱比SHEATRを示している。なお、図中の点線はストイキの位置を示しており、目標燃焼当量比TFBYAがストイキ近傍にあるときは排気ガス比熱比SHEATRが小さくなり、リッチ側またはリーン側になると比熱比SHEATRが大きくなる。そして、排気バルブ閉弁時の筒内温度TEVCが変化した場合を太線矢印で示す。ここで、図8のステップ2で算出した目標燃焼当量比TFBYAと、図10のステップ10で算出した排気バルブ閉弁時筒内温度TEVCとに応じて、排気ガス比熱比SHEATRを求める。

## 【0034】

ステップ17では、後述する図7の過給・チョーク判定手段の制御構成図と、図12の過 30 給判定TBCRG・チョーク判定CHOKEフローとにより、過給判定TBCRG及びチョーク判定CHOKEを行う。

ステップ18では、ステップ17での過給判定フラグTBCRGが0であるか否か、すなわち過給状態を判断する。過給判定フラグTBCRGが0の場合は、ステップ19へ進み、過給判定フラグTBCRGが0でない場合は、ステップ22へ進む。

## 【0035】

ステップ19では、ステップ17でのチョーク判定フラグCHOKEが0であるか否か、すなわちチョーク状態を判断する。

チョーク判定フラグCHOKEが0の場合は、ステップ20へ進み、後述する図13のフ 40 ローから、過給無し且つチョーク無し時のオーバーラップ中の平均吹き返しガス流量MRESOLtmpを算出する。

## 【0036】

一方、ステップ19で、ステップ17でのチョーク判定フラグCHOKEが0でない場合には、ステップ21へ進み、後述する図14のフローから、過給無し且つチョーク有り時のオーバーラップ中の吹き返しガス流量MRESOLtmpを算出する。

また、ステップ18で、ステップ17での過給判定フラグTBCRGが1、すなわち過給状態であり、且つステップ22でチョーク判定フラグCHOKEが0の場合は、ステップ23へ進み、後述する図15のフローから、過給有り且つチョーク無し時のオーバーラップ中の平均吹き返しガス流量MRESOLtmpを算出する。

## 【0037】

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一方、ステップ22で、ステップ17でのチョーク判定フラグCHOKEが1の場合は、ステップ24へ進み、後述する図16のフローから、過給有り且つチョーク有り時の吹き返しガス流量MRESOLtmpを算出する。

ステップ20, 21, 23, 24で吹き返しガス流量MRESOLtmpを算出した後は、ステップ25へ進む。

#### 【0038】

ステップ25では、過給の有無とチョークの有無との状態に応じて、吹き返しガス流量MRESOLtmpとオーバーラップ期間中の積算有効面積ASUMOLとを積算することで、オーバーラップ中の吹き返しガス量MRESOLを次式により算出する。

$$MRESOL = (MRESOLtmp \times ASUMOL \times 60) / (NRPM \times 360) \quad \dots (7)$$

ここで、ステップ17における過給・チョーク判定について、図7の過給・チョーク判定手段の制御構成図と、図12の過給判定TBCRG・チョーク判定CHOKEフローとを用いて説明する。

#### 【0039】

図7に示す通り、排気ガス比熱比算出手段、排気バルブ閉弁時筒内圧力算出手段、吸気圧力算出手段の各算出値に基づき、過給・チョーク判定手段は過給判定TBCRGとチョーク判定CHOKEとを行う。

図12のステップ26では、吸気圧力センサ10の信号に基づいて検出された吸気圧力PINと、図10のステップ11で算出された排気バルブ閉弁時筒内圧力PEVCとの比、すなわち吸気排気圧力比PINBYEXを次式により算出する。

#### 【0040】

$$PINBYEX = PIN / PEVC \quad \dots (8)$$

ステップ27では、吸気排気圧力比PINBYEXが1以下であるか否か、すなわち過給状態を判断する。

吸気排気圧力比PINBYEXが1以下の場合、すなわち過給無しの場合は、ステップ28へ進み、過給判定フラグTBCRG=0を0に設定し、ステップ31へ進む。

#### 【0041】

一方、吸気排気圧力比PINBYEXが1より大きい場合、すなわち過給有りの場合は、ステップ29へ進み、過給判定フラグTBCRGを1に設定し、ステップ30へ進み、図11のステップ16で算出した排気ガス比熱比SHEATRを、図22に示すテーブルから求めた空気及び燃料の混合気比熱比MIXAIRSHRとする。

#### 【0042】

図22は、混合気比熱比MIXAIRSHR算出手法であり、横軸は目標燃焼当量比TFBYA、縦軸は混合気比熱比MIXAIRSHRを示している。なお、図中の点線はストイキを示し、比熱比MIXAIRSHRは、リーン側のときは大きく、リッチ側のときは小さくなる。そして、図2のステップ2で算出した目標燃焼当量比TFBYAに対応する混合気比熱比MIXAIRSHRをテーブルから求める。

#### 【0043】

そして、ステップ30において、排気ガス比熱比SHEATRを混合気比熱比MIXAIRSHRに置き換えることで、ターボ過給や慣性過給等の過給時におけるオーバーラップ中のガス流れが吸気系から排気系へ向かう（吹き抜ける）ときにおいても、オリフィスを通過するガスの比熱比を排気ガスの比熱比から吸気混合気の比熱比に変更することにより、吹き抜けるガス量を精度良く推定し、内部EGR量を精度良く算出する。

#### 【0044】

ステップ31では、ステップ16またはステップ30で算出した排気ガス比熱比SHEATRに基づき、最小と最大とのチョーク判定しきい値SLCHOKEL, SLCHOKEHを次式により算出する。

$$SLCHOKEL = \{2 / (SHEATR + 1)\}^{\wedge} |SHEATR / (SHEATR - 1)| \quad \dots (9a)$$

$$SLCHOKEH = \{2 / (SHEATR + 1)\} ^ {1 / (SHEATR / (SHEATR - 1))} \dots \quad (9b)$$

このチョーク判定しきい値  $SLCHOKEL$ ,  $SLCHOKEH$  は、チョークする限界値を算出している。

【0045】

また、ステップ31において、制御構成上、累乗計算が困難な場合には、予め、(9a), (9b)式の計算結果を、最小チョーク判定しきい値  $SLCHOKEL$  テーブルと最大チョーク判定しきい値  $SLCHOKEH$  テーブルとして記憶しておき、排気ガス比熱比  $SHEATR$  に応じて求めてよい。

ステップ32では、ステップ26で算出した吸気排気圧力比  $PINBYEX$  が、最小チョーク判定しきい値  $SLCHOKEL$  以上で且つ最大チョーク判定しきい値  $SLCHOKEH$  以下の範囲内にあるか否か、すなわちチョーク状態を判定する。 10

【0046】

吸気排気圧力比  $PINBYEX$  が範囲内にある場合、すなわちチョーク無しと判断した場合は、ステップ33へ進み、チョーク判定フラグ  $CHOKE$  を0に設定する。

一方、吸気排気圧力比  $PINBYEX$  が範囲内にない場合、すなわちチョーク有りと判断した場合は、ステップ34へ進み、チョーク判定フラグ  $CHOKE$  を1に設定する。 20

【0047】

また、図11のステップ20の吹き返しガス流量  $MRESOLtmp$  の算出について、図13の過給無し且つチョーク無し時オーバーラップ中吹き返しガス流量算出フローを用いて説明する。 20

ステップ35では、図10のステップ9で算出された排気ガスのガス定数  $REX$  と、ステップ10で算出された排気バルブ閉弁時の筒内温度  $TEVC$  とに基づき、ガス流量算出式密度項  $MRSOLD$  を次式により算出する。 30

【0048】

$$MRSOLD = \sqrt{1 / (REX \times TEVC)} \dots \quad (10)$$

ここで、  $\sqrt{ }$  は温度及びガス定数に関する係数である。なお、制御構成上、ガス流量算出式密度項  $MRSOLD$  の算出が困難な場合は、予め、(10)式の計算結果をマップとして記憶しておき、排気ガスガス定数  $REX$  と筒内温度  $TEVC$  とに応じて求めてよい。 30

【0049】

ステップ36では、図11のステップ16で算出された排気ガス比熱比  $SHEATR$  と、図12のステップ26で算出された吸気排気圧力比  $PINBYEX$  とに基づき、ガス流量算出式圧力差項  $MRSOLP$  を次式により算出する。

$$MRSOLP = \sqrt{[SHEATR / (SHEATR - 1) \times \{PINBYEX ^ {2 / SHEATR} - PINBYEX ^ {((SHEATR + 1) / SHEATR)}\}] \dots \quad (11)}$$

ステップ37では、図10のステップ11で算出された排気バルブ閉弁時筒内圧力  $PEVC$  と、図13のステップ35とステップ36とで算出されたガス流量算出式密度項  $MRSOLD$  とガス流量算出式圧力差項  $MRSOLP$  とに基づいて、過給無し・チョーク無し時のオーバーラップ中の吹き返し流量  $MRESOLtmp$  を次式により算出する。 40

【0050】

$$MRESOLtmp = 1.4 \times PEVC \times MRSOLD \times MRSOLP \dots \quad (12)$$

また、ステップ21の吹き返しガス流量  $MRESOLtmp$  について、図14の過給無し且つチョーク有り時の吹き返しガス流量算出フローを用いて説明する。

【0051】

ステップ38では、図13のステップ35と同じく、ガス流量算出式密度項  $MRSOLD$  を前述の(10)式より算出する。

ステップ39では、図11のステップ16で算出された排気ガス比熱比  $SHEATR$  に基づき、ガス流量算出式チョーク時圧力差項  $MRSOLPC$  を次式により求める。 50

## 【0052】

$$MRSOLPC = \text{SQRT} [SHEATR \times \{2 / (SHEATR + 1)\}^{\wedge} \{ (SHEATR + 1) / (SHEATR - 1) \}] \dots \quad (13)$$

なお、制御構成上、累乗計算が困難な場合には、予め (13) 式の計算結果を、ガス流量算出式 choke 時圧力差項 MRSOLPC マップとして記憶しておき、排気ガス比熱比 SHEATR に応じて求めてよい。

## 【0053】

ステップ 40 では、図 10 のステップ 11 で算出された排気バルブ閉弁時筒内圧力 PEVC と、図 14 のステップ 38 で算出されたガス流量算出式密度項 MRSOLD と、ステップ 39 で算出された choke 時圧力差項 MRSOLPC に基づいて、過給無し・ choke 有り時のオーバーラップ中吹き返し流量 MRESOLtmp を次式により算出する。 10

## 【0054】

$$MRESOLtmp = PEVC \times MRSOLD \times MRSOLPC \dots \quad (14)$$

また、ステップ 23 のオーバーラップ中の平均吹き返しガス流量 MRESOLtmp の算出について、図 15 の過給有り・ choke 無し時の吹き返しガス流量算出フローを用いて説明する。

## 【0055】

ステップ 41 では、図 12 のステップ 30 で算出された排気ガス比熱比 SHEATR と、ステップ 26 で算出された吸気排気圧力比 PINBYEX に基づき、ガス流量算出式過給時圧力差項 MRSOLPT を次式により求める。 20

$$MRSOLPT = \text{SQRT} [SHEATR / (SHEATR - 1) \times \{PINBYEX^{\wedge} (-2 / SHEATR) - PINBYEX^{\wedge} (- (SHEATR + 1) / SHEATR)\}] \dots \quad (15)$$

なお、制御の構成上、累乗計算が困難な場合は、予め (15) 式の計算結果を、ガス流量算出式過給時圧力差項 MRSOLPT マップとして記憶しておき、排気ガス比熱比 SHEATR と吸気排気圧力比 PINBYEX とに応じて求めてよい。

## 【0056】

ステップ 42 では、吸気圧力センサ 10 の信号に基づいて検出された吸気圧力 PIN と、ステップ 41 で算出された過給時圧力差項 MRSOLPT に基づいて、過給有り・ choke 無し時オーバーラップ中吹き返しガス流量 MRESOLtmp を次式により算出する。 30

$$MRESOLtmp = -0.152 \times PIN \times MRSOLPT \dots \quad (16)$$

ここで、吹き返しガス流量 MRESOLtmp は負の値を示すことで、オーバーラップ中に吸気系から排気系へ吹き抜けるガス流量を表すことができ、これに基づいて内部 EGR 量を減じる。

## 【0057】

また、ステップ 24 の吹き返しガス流量 MRESOLtmp の算出について、図 16 の過給有り・ choke 有り時オーバーラップ中吹き返しガス流量算出フローを用いて説明する。

ステップ 43 では、図 14 のステップ 39 と同じく、ガス流量算出式 choke 時圧力差項 MRSOLPC を (13) 式またはマップから求める。 40

## 【0058】

ステップ 44 では、吸気圧力 PIN と、ガス流量算出式 choke 時圧力差項 MRSOLPC に基づいて、過給有り・ choke 有り時のオーバーラップ中吹き返しガス流量 MRESOLtmp を次式により算出する。

$$MRESOLtmp = -0.108 \times PIN \times MRSOLPC \dots \quad (17)$$

ここで、吹き返しガス流量 MRESOLtmp は負の値を示すことで、オーバーラップ中に吸気側から排気側へ吹き抜けるガス流量を表すことができ、内部 EGR 量を減じることとなる。

## 【0059】

ここで、ステップ20, 21, 23, 24で、過給の有無とチョークの有無との状態に応じて、吹き返しガス流量MRESOLtmpを算出する。そして、前述のステップ25でオーバーラップ中吹き返しガス量MRESOLを算出した後は、図9のステップ6からステップ7へ進み、前述のステップ7で内部EGR量MRESを算出する。そして、図8のステップ3からステップ4へ進み、前述の内部EGR率MRESFRを算出して、処理を終了する。

#### 【0060】

本実施形態によれば、排気バルブ閉弁時の筒内温度TEVCを算出する手段(ステップ10)と、排気バルブ閉弁時の筒内圧力PEVCを算出する手段(ステップ11)と、燃焼空燃比に応じた排気ガス組成のガス定数REXを算出する手段(ステップ9)と、少なくとも前記筒内温度TEVC、前記筒内圧力PEVC、前記ガス定数REXに基づいて、排気バルブ閉弁時の筒内ガス量MRESCYLを算出する手段(ステップ12)と、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の吹き返しガス量MRESOLを算出する手段(ステップ25)と、を備え、筒内ガス量MRESCYLと吹き返しガス量MRESOLとにに基づいて、内部EGR量MRESを算出する(ステップ7)。このため、燃焼終了後のシリンダ内部の状態量(温度TEVC・圧力PEVC・ガス定数REX)に基づき、物理式から内部EGR量MRESを算出できる。そして、温度・圧力変化による密度変化や、燃焼空燃比変化に伴うガス定数の変化による密度変化に対応でき、運転条件に関わらず精度良く内部EGR量MRESを推定できる。特に、過渡運転状態においては、シリンダ内部の状態量が刻々と変化するため、その変化していく状態量に基づいて内部EGR量MRESを算出できるので、過渡運転時の内部EGR量MRESの推定精度を向上できる。そして、内部EGR量MRESを精度良く推定することで、点火時期、燃料噴射量、バルブ開閉タイミング(オーバーラップ量)などを適切に制御できる。さらに、多次元パラメータを含む制御構築であっても、各パラメータに応じ、物理式(3式)に基づいて内部EGR量MRESを算出し、この値MRESに基づいて、各制御値を決定するため、容易に構築できる。

#### 【0061】

また本実施形態によれば、さらに排気バルブ閉弁時の筒内容積VEVCを算出する手段(ステップ8)を含んで構成され、これらの算出値に基づいて、物理式(4式)により排気バルブ閉弁時の筒内ガス量MRESCYLを算出する。このため、排気バルブ閉弁時の筒内容積VEVCを考慮して、燃焼終了後のシリンダ内部の状態量(容積VEVC・温度TEVC・圧力PEVC・ガス定数REX)に基づき、物理式(3式)から内部EGR量MRESを算出できる。この場合も、温度・圧力変化による密度変化や、燃焼空燃比変化に伴うガス定数の変化による密度変化に対応でき、運転条件に関わらず精度良く内部EGR量MRESを推定できる。また、多次元パラメータを含む制御構築であっても、各パラメータに応じ、物理式(3式)に基づいて内部EGR量MRESを算出するため、容易に構築でき、適合が容易となる。

#### 【0062】

また本実施形態によれば、排気バルブ閉弁時筒内容積算出手段(ステップ8)は、排気バルブ閉弁時のピストン位置から幾何学的に決まる筒内容積値VEVCを求める。このため、排気バルブ閉弁時の筒内容積VEVCを適切に算出して、より正確な内部EGR量MRESを求めることができる。

また本実施形態によれば、排気バルブ閉弁時筒内容積算出手段(ステップ8)は、排気バルブ閉弁時期と該時期の筒内容積とを相対的に変化させる機構を有するエンジンにおいては、その変化量に応じて、排気バルブ閉弁時の筒内容積値VEVCを求める。このため、排気バルブ閉弁時に筒内容積VEVCが変化する機構(可変バルブ閉閉タイミング、可変圧縮比)を有するエンジンであっても、容易に筒内容積VEVCを求められ、より正確な内部EGR量MRESを算出できる。そして、各値は幾何学的に決まるので、容易に算出でき、実機運転による適合させる必要が無くなり、開発が効率的に行える。

#### 【0063】

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また本実施形態によれば、ガス定数算出手段（ステップ9）は、目標燃焼当量比T F B Y Aに応じ、排気ガス組成の変化に対応するガス定数R E Xを求める（図18）。このため、目標燃焼当量比T F B Y Aに応じた排気ガス組成変化に伴う密度変化がある場合、すなわち、リーン運転、始動後、全開運転域への切り替え後における目標燃焼当量比T F B Y Aの増減がある場合にも、内部E G R量M R E Sを精度良く推定できる。そして、ガス定数R E Xは、燃料組成と空気組成とによる化学反応式から算出でき、実機運転による適合させる必要が無くなり、開発が効率的に行える。

#### 【0064】

また本実施形態によれば、オーバーラップ中吹き返しガス量算出手段（ステップ25）は、排気バルブ閉弁時の筒内温度T E V Cを算出手段（ステップ10）と、排気バルブ閉弁時の筒内圧力P E V Cを算出手段（ステップ11）と、燃焼空燃比に応じた排気ガス組成変化に対応したガス定数R E Xを算出手段（ステップ9）と、吸気圧力P I Nを算出手段（ステップ10）と、排気ガス組成変化に対応した比熱比S H E A T Rを算出手段（ステップ14）と、排気バルブ開期間と吸気バルブ開期間とのオーバーラップ中の積算有効面積A S U M O Lを算出手段（ステップ14）と、機関回転数N R P Mを算出手段（ステップ15）と、過給及びチョークの有無を判定する手段（ステップ27, 32）と、を含んで構成され、これらの算出値に基づいて、オーバーラップ中の吹き返しガス量M R E S O Lを算出する。このため、オーバーラップ中の状態量（温度T E V C、圧力P E V C、ガス定数R E X、面積A S U M O L）に基づき、物理式（7式）により吹き返しガス量M R E S O Lを精度良く算出できる。そして、状態量の変化による密度変化やオリフィス通過体積流量変化に対応でき、あらゆる運転状態において精度良くオーバーラップ中吹き返しガス量M R E S O Lを算出できる。さらに、多次元パラメータを含む制御構築においても、各パラメータに応じて物理式（3式）に基づき内部E G R量M R E Sを算出するため、容易に構築でき、適合が容易となる。  
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#### 【0065】

また本実施形態によれば、過給及びチョークの判定手段（ステップ27, 32）は、吸気圧力P I Nと排気バルブ閉弁時筒内圧力P E V Cに基づいて、吸気排気圧力比P I N B Y E Xを算出手段（ステップ26）を備え、排気ガス組成変化に対応した比熱比S H E A T Rを、過給判定手段（ステップ27）が過給有りとした場合に設定する。このため、全開運転における慣性過給時や、過給機による過給時でも精度良くオーバーラップ中の吹き返しガス量M R E S O Lを算出できる。そして、アイドル運転時などにおいてチョークが発生した場合でも精度良く吹き返しガス量M R E S O Lを算出できる。  
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#### 【0066】

また本実施形態によれば、オーバーラップ中積算有効面積算出手段（ステップ14）は、吸気バルブ開閉タイミングを算出手段（図20）と、排気バルブ開閉タイミングを算出手段（図20）と、からオーバーラップ量を算出し、このオーバーラップ量に応じて積算有効面積A S U M O Lを求める。このため、オーバーラップ量に基づいて積算有効面積A S U M O Lを算出でき、物理式（6式）による計算を簡略化することができる。

#### 【0067】

また本実施形態によれば、オーバーラップ中積算有効面積算出手段（ステップ14）は、吸気バルブリフト中の開口面積と排気バルブリフト中の開口面積とのいずれか一方の最小値を積分し、積算有効面積A S U M O Lを算出する。このため、オーバーラップ期間の積算有効面積A S U M O Lを1つのオリフィスとして疑似でき、排気系の状態と吸気系の状態とからこのオリフィスを通過する流量を簡略的に算出することができる。  
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#### 【図面の簡単な説明】

【図1】内部E G R量推定装置のシステム構成図

【図2】内部E G R率算出手段の制御構成図

【図3】内部E G R量算出手段の制御構成図

【図4】排気バルブ閉弁時筒内ガス流量算出手段の制御構成図

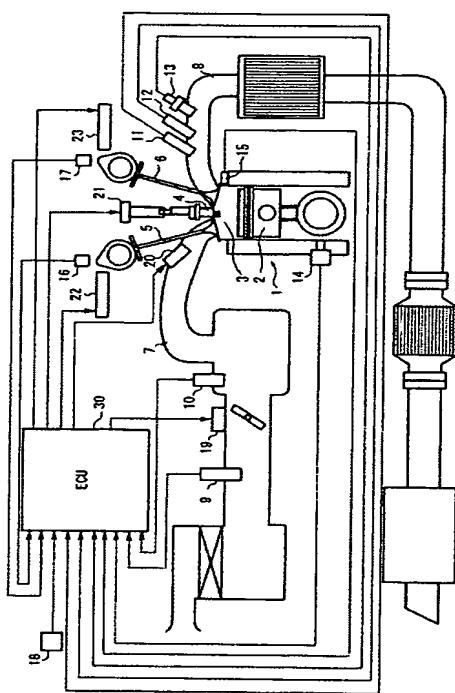
【図5】オーバーラップ中吹き返しガス量算出手段の制御構成図

【図 6】排気ガス比熱比算出手段の制御構成図  
 【図 7】過給・チョーク判定手段の制御構成図  
 【図 8】内部EGR率算出フローチャート  
 【図 9】内部EGR量算出フローチャート  
 【図 10】排気バルブ閉弁時筒内ガス量算出フローチャート  
 【図 11】オーバーラップ中吹き返しガス量算出フローチャート  
 【図 12】過給判定・チョーク判定フローチャート  
 【図 13】過給無し・チョーク無し時オーバーラップ中吹き返しガス流量算出フローチャート  
 【図 14】過給無し・チョーク有り時オーバーラップ中吹き返しガス流量算出フローチャート  
 【図 15】過給有り・チョーク無し時オーバーラップ中吹き返しガス流量算出フローチャート  
 【図 16】過給有り・チョーク有り時オーバーラップ中吹き返しガス流量算出フローチャート  
 【図 17】排気バルブ閉弁時筒内容積算出テーブル  
 【図 18】排気ガスガス定数算出テーブル  
 【図 19】オーバーラップ中積算有効面積算出テーブル  
 【図 20】オーバーラップ中積算有効面積の説明図  
 【図 21】排気ガス比熱比算出テーブル  
 【図 22】混合気比熱比算出テーブル  
 【符号の説明】  
 1 エンジン  
 5 吸気バルブ  
 6 排気バルブ  
 1 0 吸気圧力センサ  
 1 1 排気圧力センサ  
 1 2 排気温度センサ  
 1 3 O<sub>2</sub>センサ  
 1 4 クランク角センサ  
 1 5 水温センサ  
 1 6 吸気側カム角センサ  
 1 7 排気側カム角センサ  
 1 8 アクセル開度センサ  
 3 0 ECU

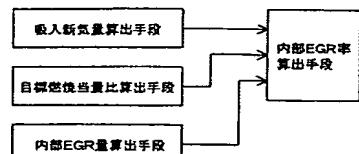
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### 【図1】



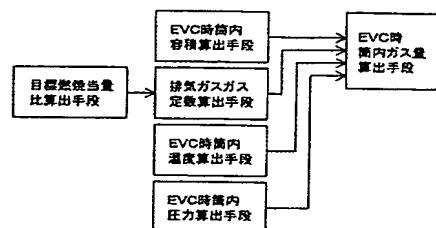
[図 2]



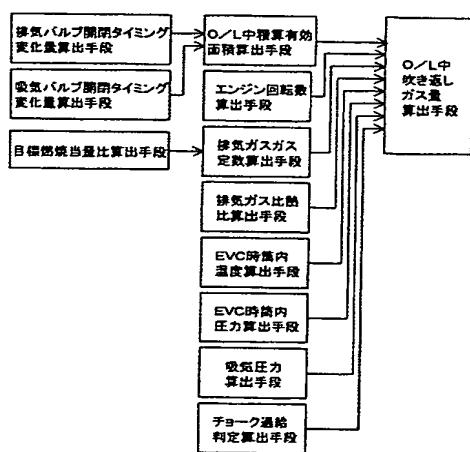
【図3】



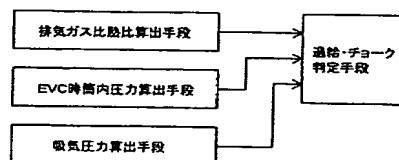
〔四〕



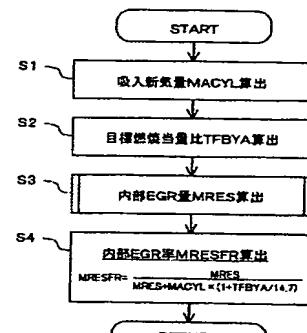
[ 5 ]



[图 7]



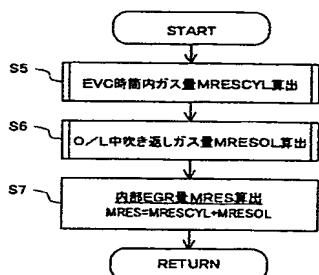
[図 8]



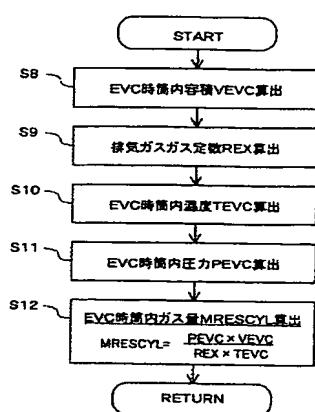
【図6】



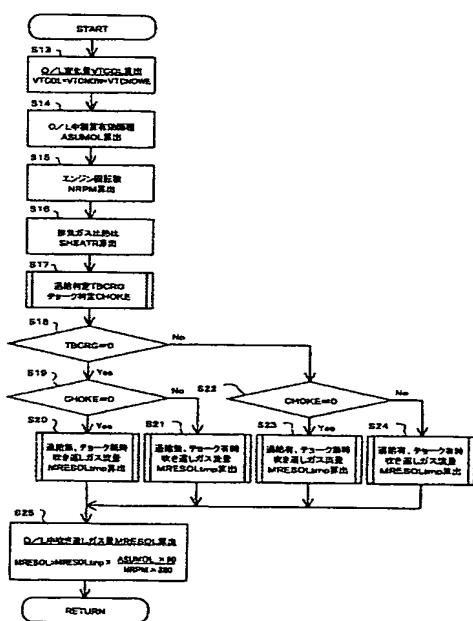
【図 9】



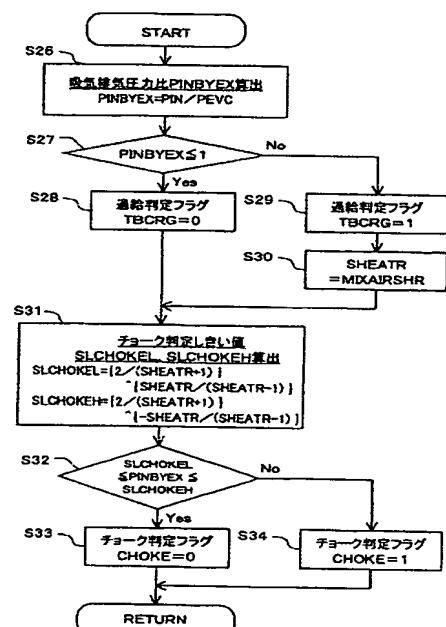
【図 10】



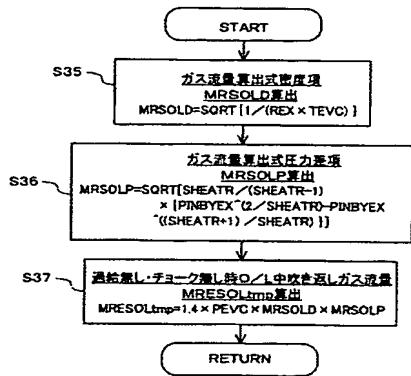
【図 11】



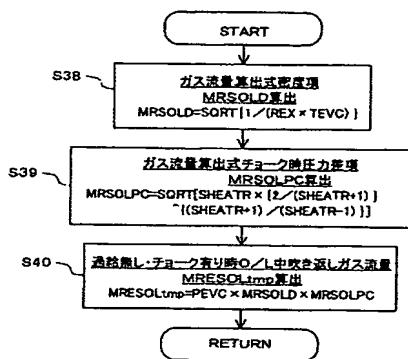
【図 12】



【図 1 3】



【図 1 4】



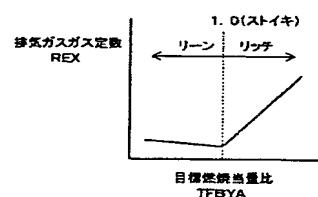
【図 1 5】



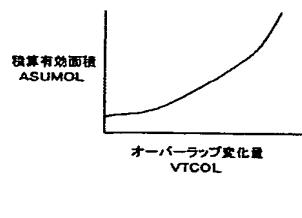
【図 1 6】



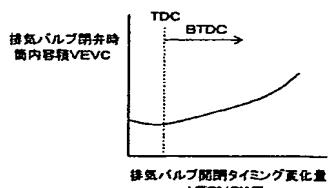
【図 1 8】



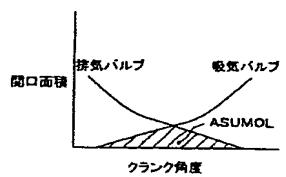
【図 1 9】



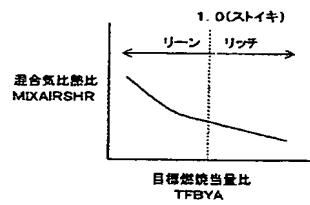
【図 1 7】



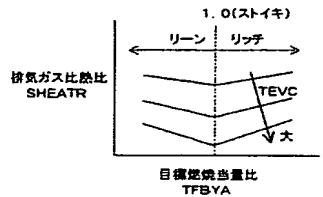
【図 2 0】



【図 2 2】



【図 2 1】



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